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THE BOTANY
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BY

L. KOLDERUP ROSENVINGE
PH. D.

AND

EUG. WARMING
PH. D., SC. D.

PART I

1. THE MARINE ALGAL VEGETATION BY HELGI JÓNSSON, PH. D.

(PUBLISHED BY THE AID OF THE CARLSBERG FUND)

COPENHAGEN
J. FRIMODT

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PREFACE.

IT was mentioned in the preface to the "Botany of the Færöes" (Copenhagen & London, 1901—1908) that, on the completion of that work, Iceland would be the one island among the dependencies of the Danish kingdom in the Atlantic which was in most need of a thorough and systematic investigation as regards its botany, and the hope was expressed that this would be commenced as early as the year 1909. This hope has been so far realized that we, the undersigned, are now able to publish the first paper on the subject, viz. "The Marine Algal Vegetation" by Dr. HELGI JÓNSSON of Reykjavík. Iceland, however, is so large compared with the Færöes that the investigation will not only be far more difficult to carry out, but will also extend over a far longer period.

We hope that specialists in botany may be able, at short intervals, to visit the island and make collections and notes. Thus, even in 1910 a young bryologist, A. HESSELBO, studied the moss-vegetation — when he took the photographs, published in the present paper — and this summer he is again paying a visit to the island, after which he will prepare an account of the moss-flora and the moss-vegetation of Iceland.

Next summer we hope that a young lichenologist will be able to set to work in a similar manner, and will be followed by others, until the work can be completed with a general account of the vegetation and the plant-geographical position of the island.

L. KOLDERUP ROSENVINGE. EUG. WARMING.

COPENHAGEN, AUG. 1912.

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1.

THE MARINE ALGAL VEGETATION OF ICELAND

BY

HELGI JÓNSSON
PH. D.

WITH 7 FIGURES IN THE TEXT

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INTRODUCTION.

It is far from being a fact that the Marine Algal Flora and Marine Algal Vegetation of Iceland can be regarded as sufficiently known; this does not apply in the same degree, however, to all parts of the coast. East Iceland, South Iceland and South-west Iceland are better known in this respect than North-west Iceland and North Iceland. Also, as is very natural, the littoral vegetation is better known than the sublittoral, as it is easier of access and may be investigated directly on the spot, while, as regards the sublittoral vegetation, one has to be content with what is obtained from dredgings.

Very little has previously been written with regard to the marine algal vegetation of Iceland. Strömfelt, who travelled in Iceland in the summer of 1883, has treated the algal flora exhaustively (see Jónsson, 31) in his valuable work "Om Algevegetationen vid Islands kuster" (70) and has given a critical review of the older literature of the marine algal flora of Iceland; but, on the other hand, he has dealt very briefly with the marine algal vegetation. He follows Kjellman in dividing the vegetation in question into a littoral and a sublittoral vegetation. Strömfelt found the littoral vegetation poorly developed in many places — he records, however, a luxuriant littoral vegetation from Reykjavík, Eyrarbakki and Eskifjörður. The sublittoral vegetation is mentioned even more briefly, and is emphasized as being more uniform than the littoral as regards its distribution and the species which compose it. Strömfelt does not make any definite statement regarding the elittoral vegetation, owing to his not having dredged in sufficiently deep water, but he considers it improbable that any vegetation worthy of notice occurs at that depth, as he did not find any rich vegetation at a greater depth than 10—12 fathoms.

The reason why Strömfelt found the littoral vegetation on the north coast so poorly developed may be two-fold: it may result

from the drift-ice having remained at the coast during the whole summer of the previous year (1882), but it may also be due to the fact that, in this case, Strömfelt went by steamer from port to port, and could scarcely have obtained a thorough knowledge of the coast in as much as the steamer usually stops only a short time at each port.

Strömfelt mentions the following algal formations: the *Fucaceæ*-formation which is reported from Hólmanes and Seley in E. Iceland; the *Laminaria*-formation, under which a subvegetation of red algæ is mentioned. Further, a *Monostroma*-vegetation is recorded as occurring near Ekifjörður at a depth of two fathoms on a sandy bottom, and a *Halosaccion*-formation at extreme low-water mark on Hólmanes. Strömfelt expresses the opinion, moreover, that a *Corallina*-formation formed by *Lithothamnion*-species must exist, but he does not say anything definite regarding this point, as he received almost all the *Lithothamnion*-species from the fishermen (70, pp. 10, 11). The description of the vegetation is evidently based on observations made in places where Strömfelt stayed for a longer time, viz. Eskifjörður and Reyðarfjörður in E. Iceland, and Eyrarbakki in S. Iceland. I have incorporated Strömfelt's observations with my own in my description of the vegetation.

Strömfelt, on the other hand, treats exhaustively of the distribution of the species along the coasts. Thus he is the first to substantiate the existence of two floral districts in the sea on the coasts of Iceland: a cold-water flora in NE. Iceland and a warm-water flora in SW. Iceland. In a table he gives a summary of the distribution of the species along the coast of Iceland, and states whether they are found in the Norwegian Polar Sea, the North Atlantic and the Greenland Sea. He records 33 species as common to NE. Iceland and SW. Iceland, 33 species as growing in NE. Iceland and absent from SW. Iceland, and 28 species as growing in the latter district and absent from the former. Thus 66 species in all are recorded from NE. Iceland and 61 species from SW. Iceland. Of the species given by Strömfelt as being found in or absent from NE. Iceland and SW. Iceland respectively, later investigations have proved that far the greater number are common to both places, but then, again, other species have been found which are characteristic of the different districts.

My description of the algal vegetation along the coast of Iceland is based mainly on my own observations, and further on

Strömfelt's work, as well as on Ostenfeld's observations. The latter mainly concern the littoral zone, and originate from E. Iceland (Hólmanes), SW. Iceland (Reykjavík, Njarðvík) and S. Iceland (Staður on the south side of Reykjanes).

Ostenfeld, moreover, has given information of the sublittoral vegetation of Myrakollur in NW. Iceland.

My own observations are drawn from various places encircling the whole of Iceland. In E. Iceland I have especially investigated Berufjörður, Reyðarfjörður and Seyðisfjörður, and everything which is narrated of the algal vegetation from E. Iceland originates from these fjords. In N. Iceland I have examined Eyjafjörður fairly accurately, from its innermost part to the submarine ridge off Hrísey, and I have, moreover, in the course of my journey, investigated the head of Húnaflói. When travelling by the mail steamer "Laura" round NW. Iceland I visited all the fjords from Skutulsfjörður to Patreksfjörður. I stayed only a short time in each fjord, as I accompanied the boat from port to port, and was only able to dredge and investigate the littoral zone in the vicinity of the towns. In SW. Iceland I have been at the south side of Breiðifjörður, and have dredged along the stretch of coast from Röst in Hvammsfjörður to Hjallasandur, and have also examined the littoral zone over a far larger area, not only round Snæfellsnes but also in Dalasysla. Round Reykjavík I have dredged and investigated the littoral zone many times. In S. Iceland I have investigated the Vestmannaeyjar most thoroughly and have, in addition, dredged and examined the littoral zone at Eyrarbakki. All remarks concerning the algal vegetation of S. Iceland are based on observations drawn from the western part of the south coast. The eastern part of the south coast from about Stokkseyri eastward is, as far as I know, a sandy coast, a "desert" devoid of algal vegetation. I have not dredged further east than round the Vestmannaeyjar, but on my trip through S. Iceland in 1901 I saw very few algæ cast ashore, which may be regarded as a sure sign that a desert lies beyond, because, where algal vegetation exists, it is quite common, with a landward wind, for large, often astonishingly large quantities of algæ to be thrown up on the shore. What might not be found then, on the south coast, where the swell of the Atlantic rolls up onto the flat shore, if any algal vegetation existed further out! Nor can it be expected that anything but a desert exists off this coast, as the bottom consists of sand, and the coast lies exposed to the sea, like the west coast of Jutland. Where, on the other hand, there

are rocks, there vegetation is sure to occur. At Vík in Myrdal near the southern point of Iceland there was, for instance, a poor vegetation on the rocks.

When one considers how great is the extent of Iceland's coastline, one cannot expect this to be sufficiently elucidated as regards the distribution of marine algæ by the few and scattered investigations which have been undertaken. For a long time, then, I nourished the hope of being able to undertake further investigations, and therefore constantly deferred publishing a comprehensive description of the algal vegetation. Now, however, I have decided to delay no longer and hope in the future to be able to make a more extensive contribution in several respects towards the elucidation of the algal vegetation.

I. LIST OF THE MARINE ALGÆ.

The following List of the Marine Algæ of Iceland is extracted from my earlier publications (Jónsson, 31, Börgesen and Jónsson, 14) and from the paper by Henning Petersen (57) on the species of *Ceramium*. It gives only the names of the species with synonyms, their distribution in the different coastal districts and some new habitats. The limitation of species is unchanged except in the case of the genus *Ceramium* and in *Clathromorphum circumscriptum* (Strömf.) which is included in *Clathromorphum compactum* (Kjellm.) as proposed by Foslie. One species, *Vaucheria sphærospora* Nordst. (Börgesen and Jónsson, 14), is omitted from the list as it can scarcely be called a Marine Alga. Of *Ceramium* 5 species are added.

Thus the number of species is: —

76	Rhodophyceæ
67	Phæophyceæ
51	Chlorophyceæ
6	Cyanophyceæ
Total... 200	species.

The coastal districts are the following (see the map, p. 7): —
East Iceland (E. Icel.), from Lónsheiði (Eystra horn) to Langanes.
North Iceland (N. Icel.), from Langanes to Hornbjarg (Kap Nord).
Northwest Iceland (NW. Icel.), from Hornbjarg to Látrabjarg.
Southwest Iceland (SW. Icel.), Breiðifjörður and Faxaflói from Látrabjarg to Reykjanes.
South Iceland (S. Icel.) from Reykjanes to Vestmannaeyjar and eastwards to Lónsheiði (Eýstra horn).

In "The Marine Algæ of Iceland" (Jónsson, 31) the district NW. Icel. is larger; it reaches from the inner end of Húnaflói to Látrabjarg instead of as now from Hornbjarg to Látrabjarg. Localities from the part of the coast which stretches from Húnaflói to Horn-

bjarg are referred to NW. Icel., in the paper mentioned above, but in the present work (cf. Jónsson, 33, p. 11) to North Iceland. These localities are: Hrútafjörður, Prestsbakki, Kolbeinsá, Skálholtsvík, Kollafjarðarnes, Broddanes and Grímsey in Húnaflói.

RHODOPHYCEÆ.

BANGIOIDEÆ.

Fam. **Bangiaceæ.**

Bangia fuscopurpurea (Dillw.) Lyngb., K. Rosenv., 61, p. 831.
E. Icel., N. Icel., SW. Icel., S. Icel.

Porphyra umbilicalis (L.) J. Ag., K. Rosenv., 61, p. 830; P. laciniata Strömf., 70, p. 34.
Common in all parts of the coast of Iceland.

Porphyra miniata (Ag.) Ag., K. Rosenv., 61, p. 826; Diploderma m., D. tenuissimum, D. amplissimum Strömf., 70, p. 33.
Found in all parts of the coast.

Porphyropsis coccinea (J. Ag.) K. Rosenv., 65, p. 69; Porphyra coccinea Jónsson, 31.
SW. Icel.: Reykjavík, S. Icel.

Conchocelis rosea Batters.
Found in all parts of the coast.

FLORIDEÆ.

Fam. **Helminthocladiaceæ.**

Chantransia virgatula (Harv.) Thur., K. Rosenv., 61, p. 824.
NW. Icel., SW. Icel.

Chantransia secundata (Lyngb.) Thur., K. Rosenv., 61, p. 824.
Found in all parts of the coast.

Chantransia Alariæ H. Jónsson, 31.
SW. Icel., S. Icel.: Eyrarbakki.

Chantransia microscopica (Naeg.) Fosl. On *Cladophora gracilis* in the littoral zone. Thallus has long hairs. Published in Börgesen and Jónsson, 14.
N. Icel.: Kolbeinsá.
The specimens mentioned under this name belong most probably to another species of *Chantransia* with a unicellular base.

Fam. **Gigartinaceæ.**

Chondrus crispus (L.) Stackh., Strömf., 70, p. 31.
NW. Icel. (cast ashore), SW. Icel., S. Icel.

Gigartina mamillosa (Good. et Wood.) J. Ag., Strömf., 70, p. 31.
Found in all parts of the coast, common in SW. Icel. and S. Icel.

Ahnfeltia plicata (Huds.) Fries, Strömf., 70, p. 31.
Cast ashore on N. Icel. and NW. Icel., common in SW. Icel. and S. Icel.

Fig. 1.

Phyllophora Brodiæi (Turn.) J. Ag. **interrupta* (Grev.) K. Rosenv., 61, p. 821.
E. Icel., NW. Icel.

Phyllophora membranifolia (Good. et Wood.) J. Ag., Strömf., 70, p. 30.
SW. Icel., S. Icel.

Actinococcus subcutaneus (Lyngb.) K. Rosenv., 61, p. 822.
E. Icel., NW. Icel.

Ceratocolax Hartzii K. Rosenv., 62, p. 34.
NW. Icel.

Fam. **Rhodophyllidaceæ.**

Cystoclonium purpurascens (Huds.) Kütz., Strömf., 70, p. 30.
N. Icel., NW. Icel. (cast ashore), common in SW. Icel. and S. Icel.

Turnerella Pennyi (Harv.) Schmitz, K. Rosenv., 62, p. 29.
E. Icel., N. Icel.

Euthora cristata (L.) J. Ag., Strömf., 70, p. 27.
Common around the coast of Iceland.

Rhodophyllis dichotoma (Lepech.) Gobi, Strömf., 70, p. 26.
Common around the coast of Iceland.

Fam. **Rhodymeniaceæ.**

Rhodymenia palmata (L.) Grev., Kjellman, 36, p. 147; Strömfelt, 70, p. 27; R. pertusa Strömf., 70, p. 28.
Very common around the coast of Iceland.

Lomentaria clavellosa (Turn.) Gaill.; Le Jol., Liste des Algues mar. de Cherb., p. 132, var. *sedifolia* Ag.
S. Icel.

Lomentaria rosea (Harv.) Thur., Le Jol., Liste des Alg. mar. de Cherb., p. 131, Fig. Harv. Phyc. Brit., T. 358 and 301.
S. Icel.

Plocamium coccineum (Huds.) Lyngb., Strömf., 70, p. 27.
S. Icel.

Halosaccion ramentaceum (L.) J. Ag., Kjellm., 36, p. 153; Strömf., 70, p. 29; H. scopula Strömf., 70.
Common around the coast of Iceland.

Fam. **Delesseriaceæ.**

Delesseria alata (Huds.) Lam., Strömf., 70, p. 24.
SW. Icel., S. Icel.

Delesseria Baerii (Post. et Rupr.) J. Ag.; **corymbosa* (J. Ag.) K. Rosenv., 61, p. 806.
There is a specimen of this plant in the herbarium of the Botanical Museum in Copenhagen; it is labelled "Islandia d. Mörck."

Delesseria sinuosa (Good. et Wood.) Lam., Strömf., 70, p. 24.
Common around Iceland.

Delesseria sangvinea (L.) Lam.; Hydrolapathum s. Strömf., 70, p. 26.
E. Icel.; rather common in SW. Icel. and S. Icel.

Fam. **Bonnemaisoniaceæ.**

Bonnemaisonia asparagoides (Wood.) C. Ag.
In the herbarium of the Botanical Museum in Copenhagen there are three specimens of this species, said to have been collected in Ice-

land. On one of the labels is written "misit Faber." In Flora Danica T. 2579 a specimen of this plant is figured, regarding which Liebmann writes: "ad littora Islandiæ pr. Reykjavik legit beatus Faber, cujus specimina mecum communicavit cl. Hofman-Bang."

Fam. **Rhodomelaceæ.**

Pterosiphonia parasitica (Huds.) Falkenberg, Die Rhodomelaceen des Golfes von Neapel. Polysiphonia p. Kjellman, 36, p. 117; H. Jónsson, 31, p. 142.

S. Icel.

Polysiphonia urceolata (Lightf.) Grev., Strömf., 70, p. 24.

Common around Iceland.

Polysiphonia fastigiata (Roth) Grev., Strömf., 70, p. 24.

NW. Iceland.; common in SW. Icel. and S. Icel.

Polysiphonia arctica J. Ag., K. Rosenv., 61, p. 800.

E. Icel., N. Icel. and NW. Icel. common; SW. Icel.

Polysiphonia nigrescens (Huds.) Harv., Kjellman, 36, p. 126.

N. Icel., SW. Icel.

Rhodomela lycopodioides (L.) Ag., Strömf., 70, p. 23.

Common around Iceland.

Odonthalia dentata (L.) Lyngb., Strömf., 70, p. 23.

Common around Iceland.

Fam. **Ceramiaceæ.**

Callithamnion Arbuscula (Dillw.) Lyngb., Strömf., 70, p. 32.

Rather common in SW. Icel. and S. Icel.

Callithamnion scopulorum C. Ag., Spec. Alg. (2), p. 176.

SW. Icel., S. Icel.

Plumaria elegans (Bonnem.) Schmitz, Syst. Uebersicht der bisher bekannten Gattungen der Florideen, Flora oder allgem. bot. Zeit., 1889; Ptilota e. Kjellman, 36, p. 172.

SW. Icel., S. Icel.

Ptilota plumosa (L.) Ag., Strömf., 70, p. 32.

N. Icel.; common in NW. Icel., SW. Icel. and S. Icel.

Ptilota pectinata (Gunn.) Kjellm., Strömf., 70, p. 32.

Common in E. Icel., N. Icel. and NW. Icel.; rather rare in SW. Icel.

Antithamnion Plumula (Ellis) Thur. *β boreale* Gobi, K. Rosenv., 61, p. 787. A. boreale Strömf., 70, p. 32.

E. Icel., N. Icel., NW. Icel., SW. Icel.

Antithamnion floccosum (Müll.) Kleen, Strömf., 70, p. 32.
E. Icel., SW. Icel., S. Icel.

Ceramium acanthonotum Carm., Kjellm., 36, p. 171.
SW. Icel., S. Icel.

Ceramium Deslongchampii Chauv., Petersen, 57, p. 108; Ceramium rubrum ex pte. Jónsson, 31.
SW. Icel.: Reykjavík (L. Kolderup Rosenvinge, $^{5}/_{6}$ 1886).

Ceramium fruticulosum Kütz., Petersen, 57, p. 108.
SW. Icel.: Seltjarnarnes (Helgi Jónsson, $^{28}/_{8}$ 1907).

Ceramium circinnatum Ag., Petersen, 57, p. 111; Ceramium rubrum ex pte. Jónsson, 31.
SW. Icel.: Stykkishólmur (Helgi Jónsson, $^{16}/_{6}$ 1897), Skerjafjörður (Helgi Jónsson, $^{10}/_{7}$ 1905).

Ceramium arborescens J. Agardh, Petersen, 57, p. 112; Ceramium rubrum ex pte. Jónsson, 31.
N. Icel.: Hrísey (Helgi Jónsson, $^{2}/_{7}$ 1898); NW. Icel.: Látravík in Aðalvík (C. H. Ostenfeld, $^{8}/_{7}$ 1896); SW. Icel.: Reykjavik (L. Kolderup Rosenvinge, $^{5}/_{6}$ 1886).

Ceramium atlanticum Petersen, 57, p. 112; Ceramium rubrum ex pte Jónsson, 31.
SW. Icel.: Grótta (Helgi Jónsson, $^{17}/_{6}$ 1908), Hafnarfjörður (Hjalmar Jensen, $^{7}/_{5}$ 1890); S. Icel.: Staður (C. H. Ostenfeld, $^{12}/_{6}$ 1896), Eyrarbakki (Helgi Jónsson, $^{31}/_{5}$ 1897), Vestmannaeyjar (Helgi Jónsson, $^{14}/_{5}$ 1897).

Ceramium rubrum (Huds.) Agardh, Petersen, 57, p. 113; Jónsson, 31, ex pte.
N. Icel., NW. Icel., SW. Icel., S. Icel.

Rhodochorton Rothii (Turt.) Naeg., K. Rosenv., 61, p. 791.
E. Icel., N. Icel., NW. Icel., SW. Icel. (common), S. Icel.

Rhodochorton repens H. Jónsson, 31.
S. Icel.

Rhodochorton minutum Suhr. Descr. in Reinke's Atlas (59), Fig. Reinke's Atlas T. 40.
SW. Icel.

Rhodochorton penicilliforme (Kjellm.) K. Rosenv., Les Algues marines du Groenland in Ann. Sc. nat., 7^{e} Sér., XIX.
E. Icel., N. Icel., NW. Icel., SW. Icel.

Rhodochorton membranaceum Magnus, K. Rosenv., 61, p. 794; P. Kuckuck, Beiträge zur Kenntniss der Meeresalgen, 1897.
E. Icel., N. Icel., NW. Icel., SW. Icel.

Fam. **Dumontiaceæ.**

Dumontia filiformis (Fl. Dan.) Grev., Strömf., 70, p. 30.
E. Icel., SW. Icel. (rather common), S. Icel.

Dilsea edulis Stackh., Sarcophyllis edulis Kjellm., 36, p. 152.
SW. Icel.

Fam. **Squamariaceæ.**

Petrocelis Hennedyi (Harv.) Batters, A list of the Marine Algæ of Berwick-on-Tweed.
N. Icel.: Hraunakrókur (O. Daviðsson), NW. Icel., SW. Icel., S. Icel.

Cruoria arctica Schmitz, K. Rosenv., 61, p. 784.
SW. Icel.

Cruoria pellita (Lyngb.) Fries, Kjellm., 36, p. 142.
SW. Icel., S. Icel.: Eyrarbakki.

Peyssonellia Rosenvingii Schmitz, K. Rosenv., 61, p. 782; Hæmatostagon balanicola Strömf., 70, p. 25?
E. Icel., N. Icel., NW. Icel., SW. Icel.

Rhododermis parasitica Batters, A list of the Marine Algæ of Berwick-on-Tweed.
NW. Icel., SW. Icel., S. Icel.

Fam. **Corallinaceæ.**

Lithothamnion glaciale Kjellm., Strömf., 70, p. 18.
E. Icel., N. Icel., SW. Icel.

Lithothamnion Ungeri Kjellm., 36, p. 91 excl. syn.; L. intermedium Strömf., 70, p. 19.
E. Icel., N. Icel., NW. Icel.

Lithothamnion tophiforme Unger, Foslie, The Norwegian forms of Lithothamnion, 1895, p. 119; L. soriferum Strömf., 70, p. 18.
E. Icel., N. Icel., SW. Icel.: Hvalfjörður (Hörring), S. Icel.

Lithothamnion flavescens Kjellm., 36, p. 98.
E. Icel.

Lithothamnion foecundum Kjellm., 36, p. 99.
E. Icel., N. Icel.

Lithothamnion læve (Strömf.) Foslie, List of species of the Lithothamnia p. 7; Lithophyllum læve Strömf., 70, p. 21.
E. Icel., N. Icel., NW. Icel., SW. Icel., S. Icel.

Lithothamnion Lenormandi (Aresch.) Foslie, The Norwegian forms of Lithothamnion, 1895, p. 150.
SW. Icel.

Phymatolithon polymorphum (L.) Foslie, List of species of the Lithothamnia p. 8; Lithothamnion polymorphum Strömf., 70, p. 19.
S. Icel.

Clathromorphum compactum (Kjellm.) Foslie, Lithothamnion compactum Kjellm., 36, p. 101; *Clathromorphum circumscriptum* (Strömf.) Fosl., Lithothamnion circumscriptum Strömf., 70, p. 20.
In all parts of the coast.

Lithophyllum Crouani Fosl., List of species of the Lithothamnia, p. 10.
N. Icel., NW. Icel., S. Icel.: Eyrarbakki.

Dermatolithon macrocarpum (Ros.) Fosl., Revised systematical survey of the Melobesieæ, p. 21; Melobesia macrocarpa Strömf., 70, p. 23.
SW. Icel., S. Icel.

Corallina officinalis L., Strömf., 70, p. 18.
N. Icel., NW. Icel., SW. Icel., S. Icel.

Hildenbrandia rosea Kütz, Strömf., 70, p. 24.
Common around the coast of Iceland.

PHÆOPHYCEÆ.

Fam. **Myrionemaceæ.**

Lithoderma fatiscens Aresch., emend. Kuck., Bemerk. I (47), p. 238.
E. Icel., N. Icel., NW. Icel., SW. Icel.

Petroderma maculiforme (Wollny) Kuck., Bemerk. II (47), p. 382.
N. Icel.

Ralfsia ovata K. Rosenv., 61, p. 900; 62, p. 94.
N. Icel.: Húsavík (Ove Paulsen), Prestsbakki; SW. Icel.

Ralfsia clavata (Carm.) Farl., Mar. Alg., p. 88; Reinke (59) Atlas T. 5 and 6, figs. 14—20; Stragularia adhærens Strömf., 70, p. 49, T. II, figs. 13—15.
E. Icel., N. Icel., NW. Icel., SW. Icel.

Ralfsia verrucosa (Aresch.) J. Ag., Reinke (59), Atlas T. 5 and 6, figs. 1—13.

E. Icel., N. Icel., SW. Icel.

Ralfsia deusta (Ag.) J. Ag., K. Rosenv., 61, p. 898.

E. Icel., N. Icel., SW. Icel., S. Icel.

Myrionema vulgare Thuret, Sauvageau, 66, p. 185.

N. Icel., SW. Icel.

Myrionema Corunnæ Sauvag., 66, p. 237.

S. Icel.

Myrionema globosum (Rke) Fosl., New or critical Norw. Algæ, p. 17; Ascocyclus globosus Rke, 58, p. 46; Atlas (59) T. 17; Phycocelis globosus K. Rosenv., 62, p. 86, figs. 19—20.

E. Icel., N. Icel., NW. Icel., SW. Icel.

Myrionema færöense Börgs., 13, p. 424.

SW. Icel.

Myrionema Laminariæ (K. Rosenv.), Dermatocelis Laminariæ K. Rosenv., 62, p. 89, fig. 21.

SW. Icel.

Ascocyclus islandicus H. Jónsson, 31, p. 149.

N. Icel.

Probably this species will prove to be identical with *A. sphærophorus* Sauv., cf. Jónsson, 31, p. 151 and Kylin.[1] The last-named author writes that *A. islandicus* without doubt is identical with *A. sphærophorus*, but he gives no particulars as to the chromatophores of the last-named species, I therefore must still regard the Icelandic plant as a distinct species.

Fam. **Ectocarpaceæ.**

Microsyphar Polysiphoniæ Kuck., Beiträge (48) p. 29.

NW. Icel., SW. Icel.

Streblonema æcidioides K. Rosenv., 61, p. 894; 62, p. 80; Phycocelis æcidioides Kuck., Bemerk. I (57), p. 234.

E. Icel., N. Icel., SW. Icel.

Streblonema Stilophoræ Cr. var. *cæspitosa* K. Rosenv., 61, p. 892.

Found in all parts of the coast.

Pylaiella littoralis (L.) Kjellm.; Ectocarpus littoralis, Kuck., 48, p. 7; Rosenv., 61, p. 881; Pylaiella littoralis, Pylaiella varia Kjellm., 35, p. 83.

Common around the coast of Iceland.

[1] Harald Kylin, Zur Kenntnis der Algenflora der Norwegischen Westküste, Arkiv för Botanik, Bd. 10, No. 1, 1910.

Ectocarpus tomentosoides Farl., New or imperfectly known Algæ of U. S., reprint from Bull. Torr. Bot. Club, Vol. XVI, 1889, p. 11, T. 87, fig. 4; K. Rosenv., 61, p. 180; Gran, En norsk form af Ectoc. tomentosoides Farl., Christiania Vidensk. Selsk. Forhandl. for 1883, No. 17; Kuckuck, Ueber Polymorphie bei einigen Phæosporeen in Festschrift für Schwendener, p. 370, figs. 5—7.

E. Icel., N. Icel., NW. Icel.; common in SW Icel. and S. Icel.

Ectocarpus tomentosus (Huds.) Lyngb., Hydr. Dan. (51) p. 132; Kjellman, 35, p. 73.

SW. Icel., S. Icel.

Ectocarpus confervoides (Roth) Le Jol., Kuck., 48, p. 19; Kjellman, 35, p. 77, ex pte.; K. Rosenv., 61, p. 883, ex pte.

Found in all parts of the coast.

Ectocarpus siliculosus (Huds.) Lyngb., Hydr. Dan. (51) p. 131; Kjellman, 35, p. 78; Kuck. 48, p. 15.

N. Icel., SW. Icel.

Ectocarpus penicillatus (Ag.) Kjellm., 35, p. 76; E. confervoides f. penicillata Kjellman, 39, p. 79.

E. Icel., N. Icel., SW. Icel.

Ectocarpus fasciculatus (Griff.) Harv., Kjellm. 35, p. 76.

SW. Icel., S. Icel.

Ectocarpus Hinksiæ Harv., Manual, p. 59; Phyc. Brit., T. 22; Sauvageau, Observations relatives à la sexualité des Phéosporées (Journal de Botanique, 1896).

S. Icel.

Fam. **Elachistaceæ.**

Leptonema fasciculatum Rke, 58, p. 50; var. subcylindrica K. Rosenv., 61, p. 879.

N. Icel., NW. Icel., SW. Icel.

Elachista fucicola (Vell.) Aresch., emend. K. Rosenv., 61, p. 878; E. fucicola Strömf., 70, p. 49. *α typica* is the most common, *β lubrica* (Rupr.) K. Rosenv. is rather common.

In all parts of the coast.

Fam. **Sphacelariaceæ.**

Sphacelaria britannica Sauvag., 67, p. 50.

N. Icel., SW. Icel., S. Icel.

Sphacelaria radicans Harv., Sauvag., 67, p. 27, fig. 14; Reinke, 60, T. III, fig. 1; Kuck., Bemerk. I (47), p. 229, fig. 4.

E. Icel., N. Icel,, SW. Icel., S. Icel.

Sphacelaria olivacea Pringsh., emend. Sauvag., 67, p. 54.

NW. Icel., SW. Icel., S. Icel.

Chætopteris plumosa (Lyngb.) Kütz., Sauvag., 67, p. 44; Strömf., 70, p. 52; K. Rosenv., 61, p. 903; Reinke, 59, Atlas T. 49—50.

E. Icel., N. Icel., NW. Icel., SW. Icel.

Fam. **Punctariaceæ.**

Omphalophyllum ulvaceum K. Rosenv., 61, p. 872, fig. 19.

E. Icel.

Punctaria plantaginea (Roth) Grev., K. Rosenv., 61, p. 871; 62, p. 71; Strömf., 70, p. 50.

E. Icel., N. Icel., NW. Icel.

Litosiphon filiformis (Rke), Pogotrichum filiforme Rke (59), Atlas, p. 62, T. 41, figs. 13—25; K. Rosenv., 61, p. 869; Kuck., Ueber Polymorphie bei einigen Phaeosporeen, Festschrift für Schwendener, p. 360.

E. Icel., N. Icel., SW. Icel., S. Icel.

Isthmoplea sphærophora (Harv.) Kjellm., 36, p. 276; Reinke (59), Atlas T. 30; Pylaiella curta Foslie, Nye havsalger, in Tromsö Museums Aarshefter, X, 1887, p. 181; Kjellman, 35, p. 85; Fosliea curta Rke, Atlas, p. 45.

E. Icel., NW. Icel., SW. Icel., S. Icel.

Stictyosiphon tortilis (Rupr.) Rke, Atlas, T. 31—32; K. Rosenv., 61, p. 868; Phloeospora tortilis Strömf., 70, p. 51; Phloeospora subarticulata Kjellman, 39, p. 78.

E. Icel., N. Icel., NW. Icel., SW. Icel.

Phæostroma pustulosum Kuckuck, Ueber einige neue Phæosporeen d. westl. Ostsee, Bot. Zeit. 1895, p. 182, T. VII; K. Rosenv., 62, p. 68, fig. 15.

E. Icel., NW. Icel., SW. Icel.

Scytosiphon Lomentaria (Lyngb.) J. Ag., K. Rosenv., 61, p. 863; 62, p. 62; Strömf., 70, p. 50.

In all parts of the coast.

Phyllitis zosterifolia Rke, 58, p. 61; K. Rosenv., 61, p. 862.

E. Icel., NW. Icel., SW. Icel., S. Icel.

Phyllitis fascia (O. F. Müll.) Kütz., K. Rosenv., 61, p. 862.
Gathered in all parts of the coast.

Fam. **Dictyosiphonaceæ.**

Coilodesme bulligera Strömf., 70, p. 48, T. II, figs. 9—12; K. Rosenv., 61, p. 862; 62, p. 61, fig. 13.
E. Icel., NW. Icel., SW. Icel.

Dictyosiphon Ekmani Aresch., Obs. phyc. 3 (7), p. 33.
SW. Icel.

Dictyosiphon Mesogloia Aresch., Obs. phyc. 3 (7); Reinke, 58, p. 64.
N. Icel.

Dictyosiphon Chordaria Aresch., Obs. phyc. 3 (7); Reinke, 58, p. 63; K. Rosenv., 61, p. 861; Coilonema Chordaria Strömf., 70, p. 51.
E. Icel., SW. Icel.

Dictyosiphon corymbosus Kjellm., 36, p. 267; Strömfelt, 70, p. 51.
N. Icel.

Dictyosiphon hippuroides (Lyngb.) Kütz.; Kjellm., 36, p. 268; Strömfelt, 70, p. 51.
N. Icel., NW. Icel., SW. Icel., S. Icel.

Dictyosiphon foeniculaceus (Huds.) Grev., Kjellman, 36, p. 269; K. Rosenv., 61, p. 859; Strömf., 70, p. 52.
E. Icel., N. Icel., NW. Icel., SW. Icel.

Fam. **Desmarestiaceæ.**

Desmarestia viridis (Müll.) Lam., K. Rosenv., 61, p. 859; Dichloria viridis Strömf., 70, p. 51.
Common around the coast of Iceland.

Desmarestia aculeata (L.) Lam., Strömf., 70, p. 51; K. Rosenv., 61, p. 857.
Common everywhere along the coast.

Desmarestia ligulata (Lightf.) Lam.
S. Icel.: Vestmannaeyjar (Ove Paulsen).

Fam. **Chordariaceæ.**

Castagnea virescens (Carm.) Thur., K. Rosenv., 62, p. 58; Eudesme virescens Strömf., 70, p. 47.
E. Icel., N. Icel., SW. Icel.

Leathesia difformis (L.) Aresch., Kjellm., 36, p. 252.

N. Icel., SW. Icel.

Chordaria flagelliformis (Müll.) Ag., Strömf., 70, p. 47; K. Rosenv., 61, p. 854.

Common everywhere along the coast.

Fam. **Chordaceæ.**

Chorda tomentosa Lyngb., Hydrophytologia Danica, p. 74; K. Rosenv., 61, p. 854.

E. Icel., N. Icel., SW. Icel.

Chorda Filum (L.) Stackh., K. Rosenv., 61, p. 853; Strömf., 70, p. 47.

E. Icel., N. Icel., NW. Icel., SW. Icel.

Fam. **Laminariaceæ.**

Saccorrhiza dermatodea (De la Pyl.) J. Ag.; K. Rosenv., 61, p. 850; Phyllaria lorea Strömf., 70, p. 42.

E. Icel., N. Icel., NW. Icel., SW. Icel.

Laminaria saccharina (L.) Lam., Kjellman, 36, p. 229; 35, p. 24; Strömf., 70, p. 42.

f. *typica;*

f. *linearis* J. Ag., Kjellman 36, p. 229; 35, p. 25; Strömf., 70, p. 42; Börgesen, 13, p. 451, fig. 85;

f. *latifolia* Kjellm., 35, p. 26; Laminaria saccharina f. latissima Kjellm., 36, p. 230; Strömf., 70, p. 43?

This species is common everywhere along the coast, especially the principal form; f. *linearis* is rarer and f. *latifolia* is only met with in E. Icel. and NW. Icel. where it occurs gregariously.

Laminaria færoensis Börges., 13, p. 454.

E. Icel., N. Icel.

Laminaria nigripes J. Ag., emend. K. Rosenv., 61, p. 842.

β *atrofulva* (J. Ag.) K. Rosenv. (l. c.); Laminaria discolor, Laminaria nigripes f. oblonga Strömf., 70, pp. 43—44.

E. Icel.

Laminaria digitata (L.) Lam., Kjellman, 36, p. 240; 35, p. 22; Strömf., 70, p. 45.

f. *genuina* Le Jol. 49; Kjellman, 35, p. 23;

f. *stenophylla* Harv. Phyc. Brit., T. 338; Laminaria stenophylla Strömf., 70, p. 45; J. Ag. De Lam., p. 18; Kjellm., 35, p. 24;

f. *cucullata* Le Jol., 49.

F. *genuina* is common everywhere; f. *stenophylla:* E. Icel., SW. Icel., S. Icel.; f. *cucullata:* E. Icel., NW. Icel.

Laminaria hyperborea (Gunn.) Foslie, 20, p. 42; Strömf., 70, p. 44; Laminaria Cloustoni Le Jol., 49, p. 577; fig., Fosl., 20, T. 1.

E. Icel., N. Icel., NW. Icel.; common in SW. Icel. and S. Icel.

Alaria Pylaii (Bory) J. Ag., emend. K. Rosenv., 61, p. 838; Alaria Pylaii and Alaria membranifolia Strömf., 70, p. 39.

f. *typica* K. Rosenv.;

f. *membranacea* (J. Ag.) K. Rosenv.

Common everywhere along the coast.

Alaria esculenta (L.) Grev., Kjellm., 36, p. 212; 35, p. 19; Alaria esculenta, Alaria linearis and Alaria flagellaris Strömf., 70, pp. 38—41; A. flagellaris K. Rosenv., 62, p. 49.

f. *australis* Kjellm.;

f. *fasciculata* Strömf.;

f. *pinnata* (Gunn.) Kjellm.

This species is exceedingly common everywhere along the coast.

Fam. **Fucaceæ.**

Fucus spiralis L., Kjellm., 36, p. 202; Strömf., 70, p. 35; Börgesen, 13, p. 472; Fucus Areschougii Kjellm., 35, p. 11.

f. *typica;*

f. *borealis* Kjellm.

E. Icel., N. Icel., SW. Icel., S. Icel.

Fucus inflatus L., M. Vahl, Fl. Danica (30), T. 1127; Foslie, Krit. Fortegnelse, Tromsö Mus. Aarshefter, IX, p. 109; Kjellm., 35, p. 11; K. Rosenv., 61, p. 834; Börgesen, 13, p. 465; Fucus evanescens Strömf., 70, p. 35; F. edentatus, F. furcatus and F. evanescens J. Ag., 3, p. 40; F. furcatus Kleen, 43, p. 29; F. edentatus De la Pyl., 15, p. 84.

f. *typica.*

F. furcatus Kleen ex pte.; F. evanescens auct. ex pte.;
F. edentatus De la Pyl.;
fig. Flora Danica (30) T. 1127; Börgesen, 13, figs. 90 and 91.

f. *evanescens* (C. Ag.)

F. evanescens C. Ag., Sp. p. 92 et auct. partim.

f. *linearis* (Huds.) K. Rosenv., 61, p. 834; F. linearis Hudson Flora anglica London 1762, Oeder Flora Danica (30) T. 351.

f. *exposita.*

F. distichus Lyngb. Hydr. Dan. (51) p. 6, exclus. syn.;
F. distichus *a*, robustior J. Ag. 3, p. 37, Kjellman 36, p. 210;
F. inflatus f. disticha Börgesen, 13, p. 465.

This species is common everywhere along the coast.

Fucus serratus L., Kjellm., 36, p. 196.
SW. Icel., S. Icel.

Fucus vesiculosus L., Kjellm., 36, p. 198; Strömf., 70, p. 34.
f. *typica,* fig. Harv. Phyc. Brit. T. 204.
f. *turgida* Kjellm.
f. *sphærocarpa* J. Ag.
This species is common everywhere.

Pelvetia canaliculata (L.) Dec. et Thur., Strömf., 70, p. 38.
SW. Icel., S. Icel.

Ascophyllum nodosum (L.) Le Jol., K. Rosenv., 61, p. 832; Ozothallia nodosa Strömf., 70, p. 34.
Common along the coast.

CHLOROPHYCEÆ.

Fam. **Protococcaceæ.**

Chlorochytrium Cohnii Wright, K. Rosenv., 61, p. 963.
SW. Icel.

Chlorochytrium inclusum Kjellm., 36, p. 320, T. 31, figs. 8—17; K. Rosenv., 61, p. 963; 62, p. 119.
E. Icel., N. Icel., NW. Icel., SW. Icel.

Chlorochytrium dermatocolax Rke, 58, p. 88; K. Rosenv., 61, p. 964; Svedelius, 71, p. 72.
N. Icel., SW. Icel.

Chlorochytrium Schmitzii K. Rosenv., 61, p. 964; 62, p. 119.
SW. Icel.

Codiolum Petrocelidis Kuck., Bemerk. (47), p. 259, fig. 27.
SW. Icel.

Codiolum gregarium Al. Braun, Algarum unicellularum genera nova et minus cognita, Lipsiæ, 1855, p. 19; Börgesen, 13, p. 517.
E. Icel.

Codiolum pusillum (Lyngb.) Kjellm., Börgesen, 13, p. 518; Vaucheria pusilla Lyngb. Hydr. Dan. 51, p. 72, T. 22.
N. Icel.

Fam. **Ulvaceæ.**

Percursaria percursa (Ag.) K. Rosenv., 61, p. 963.
SW. Icel.

Enteromorpha aureola (Ag.) Kütz., Tab. phyc., Vol. VI, T. 40, III; Ulva aureola Ag. Ic. alg. europ. (1), T. 29; Capsosiphon aureolus Gobi; Ilea fulvescens J. Ag., Ulvaceæ p. 114; ? Solenia fulvescens Ag., 2, p. 420; Enteromorpha quaternaria Ahlner in Wittr. et Nordstedt Alg. exsicc., Nos. 138 and 139.

N. Icel.

Enteromorpha Linza (L.) J. Ag., Ulva enteromorpha *a*, lanceolata Le Jol., 50, p. 42.

SW. Icel., S. Icel.

Enteromorpha intestinalis (L.) Link., emend. K. Rosenv., 61, p. 957; Börgesen, 13, p. 487.

f. *genuina* K. Rosenv. l. c. p. 957;
Enteromorpha intestinalis Strömf., 70, p. 52.

f. *micrococca* (Kütz.) K. Rosenv. l. c. p. 957.

f. *compressa* (L.) K. Rosenv. l. c. p. 958;
Enteromorpha compressa f. typica and
E. complanata f. subsimplex Strömf., 70, p. 53.

f. *minima* (Naeg.) K. Rosenv., l. c. p. 959;
Enteromorpha minima Strömf., 70, p. 53.

f. *prolifera* (O. F. Müller) Börgesen, 13, p. 490.
Enteromorpha prolifera K. Rosenv., 61, p. 960.

This species is common everywhere along the coast.

Enteromorpha clathrata (Roth) Grev., Kjellm., 36, p. 287; Ulva clathrata Le Jol., 50, p. 48 (partim); Enteromorpha compressa f. racemosa Strömf., 70, p. 53.

E. Icel., N. Icel., SW. Icel., S. Icel.

Monostroma groenlandicum J. Ag., K. Rosenv., 61, p. 954, fig. 53.

E. Icel., N. Icel., NW. Icel.

Monostroma Grevillei (Thur.) Wittr., emend. K. Rosenv., 61, p. 946.

var. *typica* K. Rosenv. l. c.
Monostroma Grevillei Wittr., 76, p. 57; Strömf. 70, p. 54 partim (e specim.).

var. *arctica* (Wittr.) K. Rosenv. l. c.
Monostroma arcticum Wittr., 76, p. 44; Monostroma latissimum Strömf., 70, p. 54.

var. *intestiniformis* K. Rosenv. l. c.
Enteromorpha intestinalis Strömf., 70, p. 58 partim (e spec.).

Var. *typica* and var. *arctica* are common along the coast; var. *intestiniformis:* E. Icel., SW. Icel.

Monostroma undulatum Wittr. 76, p. 46, T. III, fig. 9; K. Rosenv., 61, p. 945; Monostroma Grevillei Strömf., 70, p. 54 partim (e specim.).
In all parts of the coast.

Monostroma fuscum (Post. et Rupr.) Wittr., emend. K. Rosenv., 61, p. 940; M. Blyttii, Strömf. 70, p. 54.
f. *typica* is common along the coast; f. *grandis.*: E. Icel., N. Icel.

Ulva Lactuca L., K. Rosenv. 61, p. 839; Strömf., 70, p. 54.
N. Icel., NW. Icel., SW. Icel., S. Icel.

Fam. **Prasiolaceæ.**

Prasiola polyrrhiza (K. Rosenv.).
Gayella polyrhiza K. Rosenv., 61, p. 936;
Prasiola crispa subsp. marina Börgesen, 13, p. 482;
Prasiola crispa f. submarina Wille, 73, p. 13.
SW. Icel., S. Icel.

Prasiola furfuracea (Mert.) Menegh. Imhäuser, 29, p. 266; Foslie Contrib., I, p. 127; Börgesen, 13, p. 486.
E. Icel., N. Icel., SW. Icel.

Prasiola stipitata Suhr; Imhäuser, 29, p. 272; Kjellman, 36, p. 303.
E. Icel., N. Icel., SW. Icel., S. Icel.

Fam. **Ulothricaceæ.**

Ulothrix consociata Wille, 73, p. 25.
var. *islandica* H. Jónss.
N. Icel.

Ulothrix subflaccida Wille, 73, p. 29.
E. Icel., N. Icel.

Ulothrix pseudoflacca Wille, 73, p. 22, T. II, figs. 64—81.
E. Icel., SW. Icel., S. Icel.

Ulothrix flacca (Dillw.) Thur., K. Rosenv., 61, p. 935, fig. 44; Wille, 73, p. 18, T. I—II, figs. 54—63.
Common around the coast of Iceland.

Fam. **Chætophoraceæ.**

Pseudendoclonium submarinum Wille, 73, p. 29, T. III, figs. 101—134.
E. Icel.

Entoderma Wittrockii (Wille) Lagerh., K. Rosenv., 61, p. 934.
N. Icel., SW. Icel., S. Icel.

Acrochæte parasitica Oltm. Bot. Zeit. 1894, p. 208; K. Rosenv., 62, p. 114.

SW. Icel.

Acrochæte repens Pringsh., Beiträge p. 2, T. II; Huber, 28, p. 306.

NW. Icel.

Bolbocoleon piliferum Pringsh., Beiträge p. 2, T. II; Huber, 28, p. 308, pl. 13, figs. 8—12.

E. Icel., N. Icel., NW. Icel.

Fam. **Mycoideaceæ.**

Ulvella fucicola K. Rosenv., 61, p. 926, fig. 40. Pseudopringsheimia fucicola (Rosenv.) Wille in Engler u. Prantl: Die natürlichen Pflanzenfamilien, Nachträge zu I. Theil, Abtheil 2, p. 89.

E. Icel., N. Icel., SW. Icel., S. Icel.

Pringsheimia scutata Rke, 58, p. 81, Atlas T. 25.

NW. Icel., SW. Icel.

Ochlochæte ferox Huber, 28, p. 291, T. X; K. Rosenv. 61, p. 931, fig. 41.

N. Icel.

Fam. **Cladophoraceæ.**

Urospora mirabilis Aresch., K. Rosenv., 61, p. 918, fig. 35; 62, p. 106.

Common along the coast.

Urospora Hartzii K. Rosenv., 61, p. 922, fig. 38.

E. Icel., SW. Icel., S. Icel.

Urospora Wormskioldii (Mert.) K. Rosenv., 61, p. 920, fig. 36.

In all parts of the coast.

Chætomorpha tortuosa (Dillw.) Kleen, K. Rosenv., 61, p. 917.

E. Icel., N. Icel., SW. Icel.

Chætomorpha Melagonium (Web. et Mohr) Kütz., K. Rosenv., 61, p. 917; Strömf., 70, p. 55.

Probably common along the coast of Iceland.

Rhizoclonium riparium (Roth) Harv., K. Rosenv., 61, p. 913; 62, p. 103.

f. *polyrhiza* K. Rosenv., l. c. p. 913.

f. *valida* Fosl., K. Rosenv., l. c. p. 915.

f. *implexa* (Dillw.) K. Rosenv., l. c. p. 915.

E. Icel., N. Icel., SW. Icel.

Spongomorpha vernalis (Kjellm.) Wille, Acrosiphonia vernalis Kjellm., 41, p. 82.

SW. Icel.

Acrosiphonia albescens Kjellm., 41, p. 55, T. IV, fig. 21; Börgesen, 13, p. 507, fig. 103; Spongomorpha arcta Strömf., 70, p. 54, ex pte.

Common along the coast of Iceland.

Acrosiphonia incurva Kjellm. 41, p. 61.

Common along the coast.

Acrosiphonia hystrix (Strömf.) H. Jónss., 31.

f. *typica* H. Jónss., Spongomorpha hystrix Strömf., 70, p. 54, Cladophora diffusa Strömf., 70, p. 55 ex pte. (e specim.); Cladophora (Spongomorpha) arcta γ hystrix K. Rosenv., 61, p. 907.

f. *littoralis* H. Jónss.

E. Icel., N. Icel., NW. Icel., SW. Icel.

Acrosiphonia flabelliformis H. Jónss., 31.

S. Icel.

Acrosiphonia penicilliformis (Fosl.) Kjellm., 41, p. 80 forma.

E. Icel.

Cladophora rupestris (L.) Kütz., K. Rosenv., 61, p. 909; Strömf., 70, p. 55.

N. Icel., NW. Icel., SW. Icel., S. Icel.

Cladophora hirta Kütz., Kjellm., in Wittr. et Nordstedt Exsicc., No. 1041.

SW. Icel., S. Icel.

Cladophora sericea (Huds.) Aresch., 8, p. 194, forma.

N. Icel., SW. Icel., S. Icel.

Cladophora glaucescens (Griff.) Harv., Phyc. Brit. T. 196; Le Jol. Alg. mar. d. Cherb. Exsicc., 66.

SW. Icel.

Cladophora gracilis Kütz., Kjellm. in Wittr. et Nordstedt Exsicc., No. 1040.

E. Icel., N. Icel., SW. Icel.

Fam. **Gomontiaceæ.**

Gomontia polyrrhiza (Lagerh.) Born. et Flah. sur deux nouv. gen. d'Algues perfor. Journ. de Bot. Tom. II, 188, p. 163.

E. Icel., N. Icel., NW. Icel., SW. Icel.

Fam. **Phyllosiphonaceæ.**

Ostreobium Queketti Born. et Flah., Sur quelques plantes vivant dans le test calcaire des mollusques, p. 15, pl. IX, figs. 5—8.

E. Icel., N. Icel., NW. Icel., SW. Icel.

CYANOPHYCEÆ.

Fam. **Chamæsiphonaceæ.**

Pleurocapsa amethystea K. Rosenv., 61, p. 967, var.

E. Icel., N. Icel.; common in NW. Icel., SW. Icel. and S. Icel.

Fam. **Oscillatoriaceæ.**

Plectonema norvegicum Gomont, Bull. de la Soc. bot. de France, tome XLVI, 1899.

N. Icel.

Phormidium autumnale (Ag.) Gomont, emend. Johs. Schmidt, 68, pp. 348 and 410.

E. Icel.

Spirulina subsalsa Ørsted, Beretning om en Excursion til Trindelen, Krøyers Tidskrift 3. Bd., pp. 566, 1842.

N. Icel., S. Icel.

Fam. **Rivulariaceæ.**

Calothrix scopulorum (Web. et Mohr) Ag., emend. Johs. Schmidt, 68, pp. 390 and 414.

E. Icel., N. Icel.

Rivularia atra Roth, Catalecta botanica, III, p. 340, 1806.

SW. Icel.

II. LIFE-CONDITIONS OF THE MARINE ALGAL VEGETATION.

1. THE NATURE OF THE COAST.

The coast of Iceland consists partly of rock and partly of sand. The rocky coasts are rich in algal vegetation, while the sandy coast is most frequently a "desert." Here and there vegetation may be found, however, on the sandy coast, where this is not exposed to violent movement during any length of time. The vegetation then consists of short-lived species.

The Rocky Coast. This abounds in indentations of various size: inlets, fjords and bays. The size of the fjords varies greatly; for example, the largest, Faxaflói, is ten geographical miles long and twelve geographical miles broad, and Breiðifjörður is eighteen geographical miles long and ten geographical miles broad. The smaller fjords, on the other hand, are short and narrow indentations. Thus, owing to the indentations on the coast, the exposure is apt to vary greatly. The extreme points and the outer portions of the fjords have, as a rule, an exposed position, while in the interior of the fjord the water is generally calm.

The rocks on the coast consist of basalt; in some places, however, tuff-coasts exist, and especially on the south coast. The fjord-coasts of Iceland, which comprise South-west, North-west, North and East Iceland, are mainly composed of basalt. The basalt varies considerably but, as far as I have seen, it has no significance as regards the distribution of the species, and no difference is seen, for example, in the vegetation on the dolerite and the ordinary basalt coasts. What is of prime importance to the vegetation is not the rock itself but the nature of its surface. The surface is, as a rule, very uneven, being eroded by water, weather and wind, and furrowed by numerous fissures. Its nature is, therefore, such that the algæ can easily attach themselves to it.

The rocky coast is, as a rule, of solid rock, consisting of preglacial basaltic lava. Postglacial basaltic lava is found, nevertheless, in some places, as for example on Snæfellsnes. In many places, large stretches of the coast are covered with debris (Urð) from the mountains. Where the debris or the new lava predominates the surface is generally very uneven, and one then finds distinct elevations with large and small depressions interposed; such a coast is usually covered with an abundant and multifarious algal vegetation, if the conditions are in other respects favourable to the existence of algæ.

There is no range of skerries (Skærgaard) as there is, for example, on the coast of Norway. Yet a number of islands and rocks occur in the fjords, especially in Breiðifjörður. In this fjord are found indications of a range of skerries running parallel with the coast and along a considerable stretch of it, and marking the outward limit of the *Zostera*-vegetation.

The Sandy Coast. Almost the entire coast of S. Iceland is sandy shore or gravel shore. As a rule, such bottoms afford a mobile substratum because each wave which breaks on the beach shifts the particles backwards and forwards. A sandy coast is also met with, here and there, in other parts of the country, but is then found, as a rule, alternating with rocky parts; thus, the sandy or gravelly shore is often predominant at the head of small indentations which at the sides are bounded by projecting masses of rocks.

Clayey Shore is also found fairly frequently in the interior of the fjords.

The rocky coast is, as a rule, abundantly overgrown, and this is frequently the case also with the sublittoral gravel-bottom, while the sand and gravel bottoms laid bare periodically by the shifting tide are not, as a rule, overgrown, and, in any case, only with short-lived species. On clayey and muddy bottoms, on the other hand, algæ are seldom or never found, while *Zostera* often covers such a bottom and forms submarine "green meadows."

Despite the small "desert" areas, one may say that the coasts are covered with a zone of continuous algal vegetation — if we exclude the eastern portion of S. Iceland. This algal zone varies greatly in width, accommodating itself to the precipitousness of the coast. In a bay as shallow as Faxaflói the algal vegetation has a great extension seawards, while it is far more limited, for example, on the steeply descending submarine declivities in the fjords of the east coast.

2. THE OCEAN.

As regards the ocean, the chief points are its movements, temperature and salinity.

A. The Movements of the Ocean.

These are — tides, waves and currents. All these movements of the ocean are of very great importance to the life of the algæ.

a. Tides. By the alternate rise and fall of the tide a part of the shore is laid bare, and the vegetation growing there must then be capable of maintaining life in the air for a longer or shorter period. Those plants which grow highest up in the zone thus left dry, are exposed during the greater part of the period between the one flood-tide and the next, or for about 10—11 hours in every 12. The plants occurring lowest down in the zone, on the other hand, are not exposed during spring-tide for more than one hour in every 12, and they are submerged the whole time during neap-tide. The upper limit of the algal vegetation is, moreover, dependent on how high the tide rises, i. e. the height of the flood-tide.

The Height of the Flood-tide. The following data regarding the height of the flood-tide are taken from "Den islandske Lods" (1903) and from the alterations and additions to it which have been published. The height of the flood-tide is greatest in SW. Iceland and least in E. Iceland. The height of the flood-tide at spring-tide is recorded as being about 14 feet from Reykjavík (SW. Iceland), 10—11 feet from NW. Iceland, 5—5½ feet from the north coast and 5 feet from E. Iceland.

In many places there is a great difference as regards the height of the flood-tide during the spring and neap tides. To illustrate this more fully I give the following figures from some localities on the different parts of the coast: —

	Spring-tide	Neap-tide
South Iceland, Vestmannaeyjar	8—10 feet	4 feet
— Eyrarbakki	10 -	6 -
South-west Iceland, Reykjavík	cir. 14 -	4 -
— Stykkishólmur	12 -	6 -
North-west Iceland, Dyrafjörður	11 -	5—6 -
North Iceland, Akureyri	5½ -	1½ -
East Iceland, Djúpivogur	7½ -	2½ -

From Elliðaey near Stykkishólmur in SW. Iceland the height of the flood-tide during spring-tide is recorded as being 14 feet and

during neap-tide 7 feet, and it is also recorded from the latter place that the low-water at neap-tide lies about 3 feet above that at spring-tide.

When extraordinary conditions prevail the height of the flood-tide may be still greater; thus, 18—19 feet has been recorded from Reykjavík and 18 feet from Stykkishólmur.

From this it is seen that the height of the flood-tide varies greatly, which must necessarily affect the algal vegetation in several respects, especially as concerns the upper limit of its growth. Thus there is a great difference in the highest flood-mark (at spring-tide) and in the lowest flood-mark (at neap-tide). The tidal wave or the tide, moreover, shows irregularities, because neither the highest flood-mark (spring) nor the lowest flood-mark (neap-tide) is constant. The limit of the flood-tide fluctuates perpetually between a high-mark and a low-mark. The high-mark or the highest limit of the flood-tide is seen distinctly on rocky coasts from the action of the sea on the rock. On flat coasts, the high-mark can be distinguished by detached algæ and various other bodies which accompany the tidal wave and remain at the highest level reached by the water. This high-mark lies considerably higher than the upper limit of the algal vegetation.

The low-mark is not as easy to distinguish as the high-mark, but it will almost coincide with the upper limit of the *Pelvetia-Fucus spiralis* association. Above this the *Bangia* association *(Ulothrix, Bangia,* and others) is found, the extreme limit of which will almost coincide with an average water-level which, however, does not lie midway between low-mark and high-mark, but rather nearer the former. The upper limit of the algal vegetation thus lies somewhat above the limit of the flood-tide at neap-tide. The same rule holds good, of course, on a very exposed coast. That the place is exposed means that there is a heavy swell, which causes the sea to rise higher up on the coasts, both at neap-tide and at spring-tide.

By the upper limit of the marine algal vegetation is meant that boundary line above which marine algæ do not occur in the form of associations; on the other hand, no account is taken of single individuals or groups of individuals being found higher up, in crevices or pools, as such an occurrence must be considered accidental, because they are carried up to this height with the high water or by far-reaching breakers. They do live, of course, but do not thrive, and have evidently gone beyond their real area of distribution. In

this respect, however, those species should be excepted which can grow both in salt and in fresh water, as for example, *Enteromorpha intestinalis* (the principal form) and others. Naturally, such species cannot be taken into account when defining the upper limit of growth of marine algal vegetation.

If we compare the upper limit of the marine algal vegetation in Iceland with the same limit in Greenland it appears that they agree almost completely, as Rosenvinge (63, p. 89) sets the limit in Greenland almost at flood-mark at neap-tide. On the other hand there seems to be an incongruity with the Færöes, as Börgesen (11 and 12) sets the limit far above highest flood-mark in exposed places and almost at uppermost flood-mark in sheltered places.

If we institute comparisons with more distant coasts, for instance with the west coast of Sweden, the algal vegetation of which has lately been described by Kylin (43), we find that, as regards the upper limit, the case is the same as in Iceland, that is, the upper limit is coincident with an average water-level which lies higher in exposed places than in sheltered ones.

In Iceland, indeed, on a very exposed coast, marine algæ can be found rather high up, and if the sea is smooth and calm they may appear to be rather far away from the water; but on returning to the same place when the sea is in motion we see that it washes over them, and we no longer think it strange that they grow in so high a position. While the marine algal vegetation, as mentioned before, only extends upwards to an average water-level, it frequently happens on flat coasts that the land-vegetation is submerged at spring-tide. This occurs both in the interior of the fjords and on the lower islands, and may generally be distinguished by the appearance and the components of the vegetation; marine algæ, however, do not occur among such vegetation.

Some phanerogams, e. g. *Atriplex, Mertensia, Cakile,* etc., also grow below the upper limit of the littoral zone. According to Rosenvinge it happens in Greenland also that the land-vegetation is submerged at spring-tide.

b. The Swell. Here, those inequalities in the surface of the ocean which in every-day language are called waves, and that volume of water which, with a sea-wind is forced in towards the land, are treated collectively. The volume of water which is driven towards the coast by a sea-wind raises the water-level. While the tidal wave rises, the sea moved by the wind works together with

it, but when the water falls it counteracts the tidal wave; this circumstance is of great importance on exposed coasts where the wind blows frequently, as it shortens the period of desiccation. These movements in the sea are naturally somewhat irregular, but the irregularities are quite equalized in the long run, and therefore the effect of these movements may very well be regarded as constant. The high-mark which the water leaves on the coasts is due to the tide and to these movements jointly.

A frequent sea-wind has a favourable effect on the vegetation in the zone laid bare by the tide, as mentioned above, but where a frequent land-wind is blowing the effect is the reverse, as this counteracts the rise of the tidal wave and accelerates its fall, whereby the period of desiccation is prolonged.

The effect of the waves beating on the algæ is great. In exposed places, that is in places where the swell is heavy, the plants must be able to withstand the drag of the waves. The species which grow in these places therefore have a tough, leathery and narrow frond, whereas species in quiet waters have a delicate frond, often broad and brittle. The consistency of the frond thus accommodates itself to the force of the beat of the waves, and in partially exposed places, or in places where the beat of the waves is not strong, but yet fairly considerable, we find the consistency of the frond to be about midway between what it is in exposed and in calm places.

Like all other movements of the sea, the waves also are of great importance to the algal vegetation by the fact of their constantly providing fresh particles of water.

c. Currents (Fig. 2). Along the coast of Iceland the warm water of the Atlantic Ocean meets the cold water of the Arctic Ocean. The Gulf Stream washes the south coast of the country and sends an arm northward along SW. Iceland and NW. Iceland, and along the entire north coast warm water can be traced (the eastern arm of the Irminger Current) to Langanes; and from thence the arm turns toward the south along the coast of E. Iceland (Nielsen, 52, p. 13), where it mixes with water from the East Iceland polar current, which comes from the Norwegian Sea (Helland-Hansen and Nansen, 27, p. 287, where the current is called the East Iceland Arctic Current). In this manner characteristic coast-water arises at E. Iceland. Regarding this Nielsen (52, p. 13) writes that the Irminger Current "gives the waters over the coast shoal of East

Iceland a physiognomy different from that of the surrounding sea, the distribution of temperature being different even if the temperature is not in any important degree higher than in the East Icelandic polar current itself."

The conditions of the currents in N. and E. Iceland are evidently very complicated, and only the direction of the current of the warm water has been given above in outline, but as the observations are so few it is difficult to form an opinion as to how the condi-

Fig. 2. Map of Currents.
(Helland-Hansen and Nansen.)

tions of the currents along these coasts vary in other respects from year to year or according to the seasons.

Further, other current-movements occur in the coast-water which may be deemed to be of importance to the vegetation, that is, such movements as are due to varying specific gravity. In the summer (Nielsen, 52, p. 8) the surface-water along the coast is lighter on account of its mixing with fresh water. A surface-current from the coast outwards then arises, and an under-current from the depth towards the coast. In the winter the surface-water along the coast becomes heavier owing to cooling, and sinks. Then a surface-current from the ocean towards the coast arises, and an under-current from the coast towards the depth.

B. The Temperature of the Water.

a. The temperature of the ocean around the coasts is not sufficiently known, and consequently the mean values cannot be given. I give, therefore, as an example, some actual measurements, as even these may be instructive in several respects. As regards NW. Iceland, N. Iceland and the northernmost part of the coast of E. Iceland I rely on the measurements carried out during the year 1904 on board the Danish Deep Sea Exploration ship "Thor" (Nielsen, 52).

East Iceland just south of Langanes.

April 24. St. 15, 66° 09′ N. lat. 14° 26′ W. long.

178 m.

Depth (m.)	Temp. (C°)	Salinity ‰
0	0.63	34.70
25	0.74	34.72
50	0.73	34.72
100	0.71	34.72

Aug. 12. St. 99, 66° 10′ N. lat. 14° 29′ W. long.

189 m.

Depth (m.)	Temp. (C°)	Salinity ‰
0	7.60	34.43
10	7.53	34.44
25	6.90	34.51
50	5.89	34.69
75	5.20	34.78
100	4.61	34.85

Aug. 13. St. 100, 66° 16′ N. lat. 13° 36′ W. long.

284 m.

Depth (m.)	Temp. (C°)	Salinity ‰
0	8.57	34.51
10	8.31	34.51
25	6.00	34.69
35	4.87	—
50	3.58	34.88
75	3.32	34.91
100	3.08	34.92

North Iceland east of Eyjafjörður.

April 23. St. 14, 66° 32′ N. lat. 17° 50′ W. long.

175 m.

Depth (m.)	Temp. (C°)	Salinity ‰
0	1.50	34.85
25	1.65	34.87
50	1.68	34.87
100	1.70	34.85

July 21. St. 74, 66° 33′ N. lat. 18° 10′ W. long.

75 m.

Depth (m.)	Temp. (C°)	Salinity ‰
0	8.40	33.91
10	7.49	34.79
17	7.19	34.85
21	6.34	—
25	5.49	34.82
50	5.06	34.87
73	4.81	34.88

July 21. St. 73, 66° 14′ N. lat. 17° 28′ W. long. — 197 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	10.5	31.62
10	7.12	31.11
17	6.52	34.43
25	6.74	34.69
50	5.95	34.76
75	5.37	34.88
100	4.84	34.96

Aug. 15. St. 104, 66° 14′ N. lat. 17° 28′ W. long. — 226 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	8.60	34.27
10	8.52	34.27
25	7.84	34.47
35	6.71	34.60
50	5.90	34.82
75	5.63	34.86
100	5.40	34.91

North Iceland west of Eyjafjörður.

April 23. St. 13, 66° 30′ N. lat. 20° 47′ W. long. — 220 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	2.34	34.94
25	2.41	34.96
50	2.47	34.97
100	2.46	34.97

Aug. 23. St. 106. 66° 19′ N. lat. 20° 38′ W. long. — 222 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	4.50	32.18
10	4.70	32.94
17.5	5.65	33.53
25	6.30	33.89
30	6.11	33.93
37.5	4.42	33.95
50	4.27	34.34
62.5	5.45	34.75
75	5.62	34.83
90	5.84	34.94
100	6.12	35.05

April 23. St. 12, 66° 31′ N. lat. 22° 25′ W. long. — 62 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	1.20	34.76
40	1.05	34.81
60	1.05	34.81

June 2. St. 51, 66° 29′ N. lat. 22° 25′ W. long. — 62 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	3.52	34.67
10	3.49	34.67
25	3.49	34.70
60	3.49	34.70

Aug. 24. St. 107, 66° 30′ N. lat. 22° 27′ W. long. — 46 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	8.91	34.58
10	8.96	34.58
20	8.93	34.58
30	8.91	34.58
45	8.72	34.61

North-west Iceland.

April 22. St. 10, 66° 17′ N. lat. 23° 14′ W. long. — 125 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	1.42	34.69
50	2.82	34.99
120	2.94	35.05

April 23. St. 11, 66° 33′ N. lat. 23° 37′ W. long. — 84 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	2.40	34.97
82	2.97	—

June 2. St. 52, 66° 20′ N. lat. 23° 31′ W. long. — 142 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	4.25	34.92
10	4.24	34.92
25	4.17	34.98
50	4.19	34.99
75	4.25	34.99
100	4.34	35.01

Aug. 24. St. 108, 66° 19′ N. lat. 23° 27′ W. long. — 115 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	9.42	34.67
10	9.52	34.66
25	9.46	34.66
35	9.39	—
50	8.16	34.85
75	7.37	34.91
110	6.76	35.01

Almost at the boundary between NW. Iceland and SW. Iceland.

June 26. St. 61, 65° 32′ N. lat. 24° 34′ W. long. — 41 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	8.17	34.13
5	7.93	34.25
10	7.77	34.34
20	7.66	34.50
40	7.61	34.52

Aug. 26. St. 109, 65° 29′ N. lat. 24° 37′5 W. long. — 43 m.

Depth (m.)	Temp. (C°)	Salinity °/₀₀
0	10.26	34.54
10	10.20	34.54
15	10.20	34.53
25	10.21	34.54
40	10.21	34.57

The measurements recorded show distinctly the range of the temperature in April and August, 1904. By taking successively the stations 11 (April 23rd), 13 (April 23rd), 14 (April 23rd) and 15 (April 24th) it is distinctly seen how the temperature of the surface-water of the ocean along the north coast of Iceland decreases from west to east, as shown by the following figures: —

St. 11	St. 13	St. 14	St. 15
2.40°	2.34°	1.50°	0.63°

A similar decrease of warmth from west to east, but in a far lesser degree, appears to occur in the month of August.

Station 106 (Aug. 23rd) shows a much lower temperature than

was to be expected, which is unquestionably due to the water from the East Greenland polar current, as the ice was still, or had recently been, in the neighbourhood.

South Iceland.

From the ocean south of Iceland there are also measurements to hand carried out on board the "Thor" (Nielsen, 53).

South coast west of Dyrhólaey.

July 8. St. 63, 1904, 63° 32′ N. lat. 21° 30′ W. long. — 106 m.

Depth (m.)	Temp. (C°)	Salinity ‰
0	10.89	35.14
25	9.77	35.14
50	8.06	35.14
104	7.85	35.16

July 9. St. 64, 1904, 63° 08′ N. lat. 21° 30′ W. long. — 662 m.

Depth (m.)	Temp. (C°)	Salinity ‰
0	10.44	35.16
25	10.18	35.16
50	8.07	35.16
100	7.67	35.19

July 12. St. 67, 1904, 63° 16′ N. lat. 19° 17′ W. long. — 765 m.

Depth (m.)	Temp. (C°)	Salinity ‰
0	11.45	35.03
25	10.09	35.14
50	8.14	35.21
100	7.77	35.21

Aug. 31. St. 114, 1904, 63° 25′ N. lat. 20° 03′ W. long. — 150 m.

Depth (m.)	Temp. (C°)	Salinity ‰
0	11.70	34.49
10	11.70	34.51
20	11.55	34.65
30	11.31	34.92
40	11.31	35.03
45	10.95	35.07
50	9.78	35.04
75	7.97	35.22
100	7.74	35.22

South coast east of Dyrhólaey.

May 23. St. 46, 1905, 63° 51′ N. lat. 16° 25′ W. long. — 60 m.

Depth (m.]	Temp. (C°)	Salinity ‰
0	7.51	34.81
10	7.14	34.99
25	6.87	35.14
58	6.90	35.16

There are moreover some notes, given by Knudsen (44), on the temperature and salinity of the surface-water of the ocean south of Iceland. They are based upon the measurements carried out on

board the mail steamer "Laura" on its route from Scotland to Iceland during the years 1897—1904.

Between longitude 17° and 18°, near the coast of Iceland, in a south-easterly direction from Dyrhólaey, the mean temperature of the year (1897—1904) is stated (44) to be 8.8° and the mean salinity during the same period 35.19.

The main features regarding the temperature of the ocean around Iceland then are as follows — At the south coast warm, pure Atlantic water of a high (above 35 ‰) and somewhat varying salinity occurs; at SW. Iceland there is a somewhat similar sea; at NW. Iceland and N. Iceland there is Atlantic water mixed with cold water of low salinity from the East Greenland polar current; and lastly, at E. Iceland Arctic water occurs (with a temperature of 0° to 2° and salinity from 34.6 per cent. to 34.9 per cent. [Helland-Hansen and Nansen, 27, p. 287]): the East Iceland polar current mixed with water from the Atlantic current.

The change of temperature in the surface-layers of the water, the cooling process during winter and the heating process during summer, reaches down almost as deep as the algal vegetation, and is consequently of no slight importance to the latter.

b. The Temperature in the Fjords. Respecting the temperature of the surface-water of the ocean throughout the year information is given in the "Meteorologisk Aarbog" (Meteorological Yearbook) regarding three stations in Iceland: Papey, Grímsey and Stykkishólmur. The following figures show the seasons' mean temperature of the ocean for a period of five years (1902—1906), chosen arbitrarily. Grímsey is omitted, however, as the observations there have often been incomplete.

	Winter	Spring	Summer	Autumn
Papey (E. Iceland)	0.9°	1.7°	6.0°	4.3°
Stykkishólmur (SW. Iceland).	0.4°	1.8°	9.6°	6.4°
Vestmannaeyjar[1] (S. Iceland).	4.1°	6.1°	10.4°	7.0°

The winter in Papey is warmer than in Stykkishólmur, and the monthly mean temperatures during the winter, of the period mentioned, are there all positive; while in Stykkishólmur, February (— 0.8) and March (— 0.2) have negative numbers. The summer is much warmer

[1] The figures for the Vestmannaeyjar constitute the mean of the period from July 1st, 1877 to Dec. 31st, 1906. According to Þorvaldur Thoroddsen, Lysing Islands, 2. Bd., pp. 350—351, Kaupmannahöfn 1910.

in Stykkishólmur. A comparison of these two places is, however, not equivalent to a comparison between E. Iceland and SW. Iceland, the situation of the stations being quite different. Papey is an island lying isolated in the ocean; Stykkishólmur, on the other hand, is a good example of the thermal conditions existing in the calm fjords.

Regarding the temperature at various depths in the interior of the fjords some observations are to hand made during the summer. These are, however, too few and scattered to be given in mean values. I give, therefore, as an example, some actual measurements from different parts of the coast of Iceland.

In East Iceland the measurements of temperature were carried out on board the Survey vessel "Diana" (Fisheries' Report ("Fiskeri-Beretning") for the financial year 1899—1900), and of these the following are given: —

	Depth in fathoms	Temp. (C°)
Hellisfjörður ($^{19}/_{5}$)	0	1.7
	10	1.6
Laðmundarfjörður ($^{7}/_{6}$)	0	5.0
	cir. 33	1.5
Bakkafjörður ($^{13}/_{6}$)	0	8.0
	7	2.5
Vopnafjörður ($^{20}/_{6}$)	0	4.5
	$13^{1}/_{2}$	1.8
Finnafjörður ($^{17}/_{6}$)	0	3.8
	$8^{1}/_{2}$	2.4
Finnafjörður ($^{18}/_{7}$)	0	6.5
	5	6.3
Breiðdalsvík ($^{16}/_{8}$)	0	4.6
	Bottom	4.3

The low bottom-temperature in June is probably due to the East Iceland polar current.

In addition to these Sæmundsson[1] has published the following measurements of the temperature and salinity of the surface of the fjords in East Iceland.

	Temp. of the surface (C°)	Salinity ‰	
Djúpivogur ($^{15}/_{8}$)	9.0	29.47	high-water.
—	7.4	33.14	low-water.
Fáskrúðsfjörður ($^{19}/_{8}$)	10.0	33.67	at Búðir.
—	9.5	32.23	at Mjóeyri.
—	9.4	33.54	at Brimnes.
—	9.0	32.19	at Höfði.
— ($^{20}/_{8}$)	7.0	34.71	at Kolfreyjusstaður.

[1] Bjarni Sæmundsson, Fiskirannsóknir, 1898, Andvari, XXIV árg.

	Temp. of the surface (C°)	Salinity ‰	
Vattarnes ($^{21}/_{8}$)	8.5	34.58	near land.
Eskifjörður ($^{13}/_{8}$)	9.3	1.31	in the fjord, after rain.
— ($^{24}/_{8}$)	5.0	6.73	near land, outflowing current.
— —	5.0	23.71	out in the fjord, in outflowing current.
— —	5.0	34.45	out in the fjord, in inflowing current.
Norðfjörður ($^{27}/_{8}$)	7.5	34.45	near land.
Mjóifjörður ($^{30}/_{8}$)	6.5	33.00	at Brekka.
Seyðisfjörður ($^{7}/_{8}$)	9.5	9.23	head of the fjord.
— ($^{8}/_{8}$)	7.5	22.01	—
— —	8.0	22.01	out in the fjord.
— —	8.5	25.04	—
— —	7.8	30.65	—
— —	7.5	31.96	—
— ($^{31}/_{8}$)	7.0	34.45	at Skálanes.
— ($^{1}/_{9}$)	7.0	34.45	at Brimnes.
— ($^{3}/_{9}$)	6.5	33.01	at Dvergasteinn.
Borgarfjörður ($^{4}/_{9}$)	7.1	34.45	out in the fjord.
Vopnafjörður ($^{5}/_{9}$)	7.5	33.27	near land.

From the most westerly part of the north coast and from the northern part of the north-west coast as also from Breiðifjörður measurements are to hand of the temperature and salinity of the ocean at various depths in the interior of the fjords taken by Bjarni Sæmundsson (Fiskirannsóknir, 1908, Andvari, XXXIV árg.) of which the following are given: —

	Depth in metres	Temp. C°	Salinity ‰
North coast,			
Steingrímsfjörður ($^{31}/_{7}$)	0	10.8	27.4
	15	9.7	
	30	9.2	34.3
	55	3.2	34.5
Steingrímsfjörður ($^{2}/_{8}$)	0	10.6	34.0
	15	9.9	
	35	7.8	34.6
	70	5.8	34.7
	100	4.2	34.7
Hrútafjörður ($^{7}/_{8}$)	0	7.5	34.6
	15	6.0	
	30	4.8	34.7
	44	4.5	35.0
North-west coast,			
Mjóifjörður, the inner part ($^{20}/_{7}$)	0	11.8	30.6
	25	6.5	34.5
	50	3.2	34.9

	Depth in metres	Temp. C°	Salinity ‰
Skötufjörður, the inner part ($^{16}/_{7}$)	0	11.4	30.5
	15	8.9	
	35	7.9	34.3
	70	7.4	34.7
	105	4.6	34.7
Isafjarðardjúp, $1^{1}/_{2}$ mile NW. of Ögurnes ($^{18}/_{7}$)	0	11.8	32.2
	15	11.5	
	35	8.5	34.0
	70	6.8	34.9
	100	6.6	35.5
South-west coast,			
Skarðsstöð in Breiðifjörður ($^{13}/_{8}$)	0	10.9	34.0
(outside)	8	10.8	34.5
Skarðsstöð	0	11.1	24.8
(near land)	6	11.0	34.3

Bjarni Sæmundsson has kindly given me the permission, moreover, to make use of his hitherto unpublished measurements of the temperature of the ocean at SW. Iceland (Breiðifjörður and Faxaflói), in the interior of the fjords, from the summer of 1909. Of these the following are given: —

Breiðifjörður	Depth in metres	Temp. C°	Salinity ‰
Stykkishólmur (the port $^{5}/_{7}$)	0	10.6	35.1
About $^{1}/_{2}$ a mile SE. of Vaðstakksey ($^{7}/_{7}$)	0	10.1	34.2
	15	10.1	
	30	10.1	34.6
	63	10.0	35.1
About $^{1}/_{2}$ a mile SE. of Hrappsey ($^{10}/_{7}$)	0	11.5	33.9
	15	10.8	
	30	10.7	34.0
	70	10.5	34.2
Kolgrafarfjörður, the interior ($^{17}/_{7}$)	0	11.0	33.9
	10	10.6	
	20	10.6	34.2
	35	10.5	34.1
Kolgrafarfjörður, the mouth ($^{18}/_{7}$)	0	9.8	34.7
	15	9.7	34.8
Hvammsfjörður about 2 miles SE. of Lambey ($^{10}/_{7}$)	0	11.4	32.7
	15	11.0	
	30	11.0	33.7
	45	10.9	34.1

Faxaflói	Depth in metres	Temp. C°	Salinity ‰	
5 miles SW. of Akranes ($^{26}/_{7}$)	0	11.5	34.4	
	15	10.6		
	30	9.2	34.7	
	60	7.8	34.9	
Knararnes	0	14.0	34.0	
About 2 miles SE. of Þormóðssker ($^{31}/_{7}$).....	0	12.2	34.6	
	15	10.2		
	30	9.5	34.6	
	45	9.1	34.7	
Borgarnes ($^{3}/_{8}$).....	0	12.4	26.9	high-water.
— ($^{5}/_{8}$).....	0	12.4	18.9	low-water.
Within Seleyri	0	11.2	8.8	
	5	10.6	14.7	
Borgarfjörður, the mouth ($^{7}/_{8}$)	0	11.7	28.9	
	10	11.6		
	20	11.5	34.4	
Hvalfjörður, Hvammsdjúp ($^{13}/_{8}$)	0	11.6	33.4	
	15	11.4		
	30	11.2	34.0	
	60	11.1	34.2	
Hvalfjörður, Galtarvíkurdjúp	0	11.7	33.9	
	15	11.5		
	30	11.1	34.0	
	50	11.1	34.4	
	85	11.0	34.3	

From the measurements given above it will be seen that the temperature of the water in the interior of the small fjords is nearly the same from surface to bottom, while a regular decrease of warmth is immediately felt with the increase of depth in the more open waters. The temperature of the fjord-water is evidently dependent on the climate of the country; but regarding the temperature, during winter, for instance, we know nothing. Nor am I prepared to treat of the distribution of warmth in the coastal water in a more exact manner, as from the scattered observations made during the summer, which are at our disposal, no satisfactory results can be arrived at regarding the thermal conditions in which the algal vegetation exists all the year round.

C. The Salinity.

The degree of salinity is given above, together with the temperature.

a. The Sea. South of Iceland the salinity varies but slightly, with the exception of the coastal water itself. During the summer, at any rate, the salinity of the coastal water must be considerably lower on account of the great amount of fresh water brought down by all the rivers of the south. On the other coasts and especially those of N. and E. Iceland the salinity varies according to whether the layers of water originate from currents which are deficient in salt or from the Irminger current, and also with the amount of fresh water streaming out from land. At station 106 (see above) the inferior salinity is evidently due to cold water from the Greenland current, and at station 73 it is probably due to fresh water.

b. The Fjords. The salinity inside the fjords varies considerably and the variation is dependent upon the amount of fresh water which intermingles with the water in the fjord, partly in the form of river water and partly in the form of precipitated moisture. The lowest salinity in the fjords was 1.31 ‰ in Eskifjörður after rain. Heavy rainfalls must be capable of causing such an inferior salinity in other places also, especially in narrow fjords, but this will not last long, and as the littoral algæ can endure heavy showers during low-tide, they will not suffer to any extent worth mentioning.

In places where the salinity is as low as in Seyðisfjörður (9.23 ‰), where a rather large river disembogues, the algal vegetation occurs sparingly, although algæ are found, especially green and brown algæ. At a place like Borgarnes, where the salinity is low (18.9; 26.9) on account of fresh water from Hvítá, the algal vegetation occurs more abundantly than at the very head of Seyðisfjörður by the river, but the inferior salinity excludes certain species, for instance, *Polysiphonia fastigiata*, although *Ascophyllum* occurs abundantly. Further out, where the sea is more saline, it is not absent.

It is especially in the surface-water of the fjords that the salinity varies so much. It is greater in the large open fjords, such as Faxaflói, than in the small land-locked fjords, such as Hvalfjörður, a circumstance which must certainly be due to river-water. The figures given show also that the salinity of the surface-water of the smaller fjords is less in the inner part than in the outer part. The same difference seems to appear also between the deeper layers of water of the inner and outer parts.

As a rule, the salinity of the deeper layers is higher and more stable, which must be beneficial to the vegetation in the depths.

3. THE AIR.

The climate is of special importance to that part of the algal vegetation which is exposed during low-tide. The temperature is possibly of least importance in a climate where high and very low degrees of temperature do not occur, or are, at any rate, rare. The degree of humidity of the air and the cloud-covering are, on the other hand, highly important to the algal vegetation which is left dry. The movements of the air are also of importance, especially as it produces movements in the sea.

A. The Temperature.

The following means (19 years)[1] from a number of stations on different parts of the coast are here given for the elucidation of the thermal conditions.

	Winter	Spring	Summer	Autumn	The year
E. Iceland					
Papey	— 1.1	0.1	6.0	3.3	2.1
Berufjörður	— 1.4	0.8	7.6	3.5	2.6
N. Iceland					
Raufarhöfn	— 4.0	— 1.9	6.5	1.6	0.5
Grímsey	— 2.3	— 1.5	6.1	2.9	1.3
SW. Iceland					
Stykkishólmur	— 2.2	0.8	8.9	3.9	2.9
S. Iceland					
Vestmannaeyjar	1.1	3.8	9.7	5.2	5.0
Eyrarbakki	— 2.0	2.1	10.2	3.5	3.5

From the figures given above it will be possible to form an opinion of the thermal conditions in the places mentioned, and these are altogether such that an algal vegetation left dry can thrive everywhere along the coast. The extremes will not have a sufficiently injurious effect on the vegetation for it to be noticeable in the long run. High degrees of temperature, about 20° C for example, occur rarely in the summer, and will have no permanent effect. Very low degrees of temperature in the winter will not injure the vegetation left dry to any extent worth mentioning, as it is then partly protected by snow (at the very top) and partly by ice.

I do not consider the cold in the winter injurious to the vegetation which is left dry, as the algæ certainly endure being frozen fairly well. At least I have seen uppermost in the littoral zone,

[1] Willaume-Jantzen, Meteorologiske Middeltal og Extremer for Færöerne, Island og Grönland, Kjöbenhavn, 1899.

early in May, algæ which had been frozen hard during the night, apparently quite unharmed and alive when thawed, nor could one perceive next day that they had suffered at all; but, as I was travelling, I was not able to observe them more than these two days. It is also a foregone conclusion that the algæ left dry must freeze in the winter when the cold is severe, but it does not appear that they suffer thereby.

If the cold cannot be said to have any directly injurious effect, yet indirectly it may hurt the vegetation (though not to any great extent) by the fact that the water freezes and the beach becomes ice-covered. During severe winters a covering of ice may be found during the greater part of the winter in the smaller fjords, and especially where the fjord-water is abundantly mixed with fresh water, and even if the winters are quite mild, yet from time to time the water next the beach may freeze. In the littoral zone and on rocks which are laid bare during low-tide, the ice forms in accordance with the substratum, and if this is uneven the ice breaks. At high-water the ice-covering is lifted up; the pieces of ice may then freeze together again, and break once more with the next ebb-tide. During spring-tides in particular these movements are rather considerable and the plant-covering may be a good deal damaged thereby: but if one regards the coasts in their entirety these disturbances will prove to be of small importance.

The drift-ice is much more dangerous to the algal vegetation as the icebergs scrape the rocks with which they come in contact. Strömfelt, when travelling in Iceland in 1883, the year following one of the years notable on account of the great quantity of ice, found the littoral vegetation poorly developed in the north country. This most certainly resulted from the drift-ice having blockaded the coast during the whole summer of 1882. In the summer of 1898, I saw on the promontory between Seyðisfjörður and Loðmundarfjörður distinct signs of the drift-ice which had been there in the spring. The injurious influence of the drift-ice consists mainly in the fact that it scrapes away the vegetation from the parts with which it comes in contact; possibly also in the fact that it reduces the temperature to far below normal. That the plants suddenly find themselves in a much colder medium than they are accustomed to must produce a check upon them, particularly on the more sensitive species. The marine plants, however, are less affected by this than the land vegetation. As a rule, ice-years occur at fairly long intervals;

consequently the damage which the ice causes is not noticeable in the long run, it is noticed chiefly in the same year or the year following, and is remedied comparatively quickly.

B. The Humidity.

Very great importance must be ascribed to this as regards the algal vegetation left exposed. During the period of desiccation there is always the danger of the evaporation becoming too great, especially if the air is dry. The more humid the air, the better the algæ will be able to maintain life in it. The following figures from four places, each situated on a different part of the coast, show the mean humidity of the air as percentages (Willaume-Jantzen l. c.).

	Winter	Spring	Summer	Autumn
E. Icel. Berufjörður (23 years).....	77	78	81	80
N. Icel. Grímsey (21 years)	83	83	85	86
SW. Icel. Stykkishólmur (20-23 years) .	88	85	83	86
S. Icel. Vestmannaeyjar (12 years)	81	79	82	81

As a comparison with the Færöes might be of interest, the figures showing the mean humidity as percentages at Thorshavn Willaume-Jantzen, l. c.) are appended.

	Winter	Spring	Summer	Autumn
Thorshavn in the Færöes (25 years)..	81	79	84	84

From these figures it appears that the humidity of the air in Berufjörður is less than in the Færöes while the humidity of the air at Grímsey and also at Stykkishólmur is greater than in the Færöes. The humidity of the air in the winter and the spring in the Vestmannaeyjar and in the Færöes is the same, while at the latter place it is a little greater in the summer and autumn.

C. Precipitation, Amount of Cloud, Foggy days, Wet days.

a. Precipitation. The following figures show for purposes of comparison the mean downfall in millimetres at four places in Iceland, one on each coast, and at Thorshavn in the Færöes (Willaume-Jantzen, l. c).

	Winter	Spring	Summer	Autumn	The year
E. Icel. Berufjörður (23 years)...	348.0	222.7	203.7	340.3	1114.7
N. Icel. Grímsey (16-22 years)...	83.5	64.8	85.6	139.9	373.8
SW. Icel. Stykkishólmur (18-22 yrs.)	191.5	115.2	113.6	203.8	624.1
S. Icel. Vestmannaeyjar (15 years)..	354.1	257.3	252.1	402.2	1265.7
Thorshavn in the Færöes (25 yrs.).	510.9	485.2	272.4	324.6	1593.1

As shown by the figures there is a considerable difference in the amount of precipitated moisture. That of Thorshavn is greatest, next come the Vestmannaeyjar, followed by Berufjörður. The precipitation at Stykkishólmur is not more than half that in the Vestmannaeyjar, and that of Grímsey is not more than a fourth part of that in the Vestmannaeyjar.

b. Mean Amount of Cloud (Willaume-Jantzen, l. c.). Scale 0—10.

	Winter	Spring	Summer	Autumn
E. Icel. Berufjörður (23 years)	6.4	6.6	6.9	6.6
N. Icel. Grímsey (22 years)	8.5	8.2	7.9	8.5
SW. Icel. Stykkishólmur (22 years)	7.1	6.4	6.0	6.9
S. Icel. Vestmannaeyjar (18 years)	6.2	6.1	6.1	6.3
Thorshavn in the Færöes (25 years)	7.4	7.1	7.7	7.5

The amount of cloud is greatest in Grímsey, and there is no great difference between the remaining three coast-stations in Iceland. In Thorshavn, however, the amount of cloud is considerably greater and consequently this place approximates to Grímsey.

c. Foggy and Wet days. Mean number of Foggy days (Willaume-Jantzen, l. c.).

	Winter	Spring	Summer	Autumn	The year
E. Icel. Berufjörður (23 years).	44.0	52.0	67.0	49.0	212
N. Icel. Grímsey (22 years) ...	2.4	13.0	31.0	7.0	53
SW.Icel.Stykkishólmur(22 years)	1.0	2.6	4.1	1.3	9
S. Icel. Vestmannaeyjar (18 years)	7.0	12.0	21.0	12.0	52
Thorshavn in the Færöes (25 yrs.)	3.0	10.0	29.0	9.0	51

The number of foggy days in Berufjörður is remarkably high, and at Stykkishólmur is extremely low. In Grímsey the number is much lower during the winter months, and higher during the summer months than it is in the Vestmannaeyjar; there are also small differences during spring and autumn. There are only small differences between the Færöes and the Vestmannaeyjar, except in the winter, when the Vestmannaeyjar have twice as many foggy days.

Mean number of Wet days (Willaume-Jantzen, l. c.).

	Winter	Spring	Summer	Autumn	The year
E. Icel. Berufjörður (23 years).	52	43	34	48	177
N. Icel. Grímsey (22 years) ...	40	29	29	45	143
SW.Icel.Stykkishólmur(22 years)	58	47	40	52	197
S. Icel. Vestmannaeyjar (18 years)	64	55	47	59	225
Thorshavn in the Færöes (25 yrs.)	81	66	58	74	279

At all seasons the number of wet days is highest in the Færöes

and in the Vestmannaeyjar, yet considerably higher in the former place. Grímsey has the fewest wet days, and Berufjörður and Stykkishólmur have somewhat similar numbers.

It is in the spring and the summer especially that the desiccation, during the period of exposure, may have an injurious effect in the zone laid bare along the coast. The amount of cloud is of course important, since clouds diminish the danger of desiccation, but the mean figures are not sufficiently elucidatory. Bright sunny days are not propitious to the vegetation left exposed, especially if several such days occur in succession; and if this takes place at neap-tide, the vegetation which is found above *Pelvetia-Fucus spiralis* is in danger. Although the weather in Iceland varies greatly, longer periods which are damp or dry often occur. Clear days are not uncommon in the spring and summer, and periods of even a week or more of bright weather are not rare. On bright sunny days in summer the temperature may rise rather high; I have measured 20° C. on such a day in a pool in the littoral zone, in the plant-covering itself, and the temperature of the air may rise even higher.

The periods of bright and dry weather are certainly of importance as regards the upper limit of growth of the algal vegetation during the summer. The Færöes are probably less favoured by clear weather than Iceland, and the difference in the upper limit of growth of the algal vegetation in Iceland and in the Færöes may possibly be partly explained by this.

D. Winds.

The following figures show the annual percentage (Willaume-Jantzen, l. c.) of the winds: —

	Berufjörður	Grímsey	Stykkishólmur	Vestmannaeyjar
N.	6	8	3	13
NE.	24	18	18	3
E.	4	20	20	23
SE.	6	16	16	9
S.	8	4	11	8
SW.	15	5	10	10
W.	4	12	7	8
NW.	23	7	3	4
Calm	10	10	12	22

It happens rather frequently that the winds are stormy and, as an example, the annual percentage of storms for Stykkishólmur (from $^{1}/_{9}$ 1845 to $^{31}/_{2}$ 1892) may be given: — N. 32, NE. 61, E. 13, SE. 17, S. 44, SW. 31, W. 26, NW. 11.

The frequency of "calm" is 10 % at Grímsey and in Berufjörður and the frequency of "wind" is therefore 90 % in both places; at Stykkishólmur the frequency of "calm" is 12 % and that of "wind" 88 %; in the Vestmannaeyjar the frequency of "calm" is 22 % and that of "wind" 78 %.

At Thorshavn, in the Færöes, the annual "calm" is 11 % and the frequency of "wind" 89 %, somewhat the same, therefore, as at Stykkishólmur and greater than in the Vestmannaeyjar.

4. LIGHT.

The influence of light on the distribution of the algal associations and on their appearance is, as is well-known, exceedingly great. Without doubt most investigators assume that the main division of algal vegetation into a green, a brown and a red zone is due to the quality of the light, but one cannot on that account consider the intensity of the light to be of no importance. To what extent the shades of colour in the red algæ are to be regarded as an adaptation to the intensity of the light or to the quality of the light, I find rather difficult to decide.

I agree with Berthold and Oltmanns in thinking that the *Florideæ* may be characterized as shade-plants in the same sense that we speak of shade-vegetation in lava-clefts and in other places where there is a faint light. By shade-plants I understand plants which prefer feebly illuminated spots, and do not, as a rule, thrive in the full light of day. In the tidal region (Part VI) the littoral *Florideæ* evidently prefer crevices and grottoes, i. e. feebly illuminated places, and thus prove themselves to be shade-plants.

I shall not enter more fully into the question of light, as I have made no experiments in that connection and, moreover, the subject requires to be reinvestigated (Oltmanns, 54).

III. THE HORIZONTAL DISTRIBUTION OF THE SPECIES AND THE COMPONENTS OF THE ALGAL FLORA.

In the following list (Table I) of the hitherto known Marine Algæ of Iceland a letter (A, B_1, B_2, C, D, E_1, E_2) is placed before each species, showing to which plant-geographical group I refer it (cf. Börgesen and Jónsson, 14). A indicates the arctic group, B_1 sub-division 1 of the subarctic group, B_2 sub-division 2 of the subarctic group, C the boreal-arctic group, D the cold-boreal group and E the warm-boreal group. The letter *c* placed after the name of the species indicates that it has been found in all the five coastal districts (E. Icel., N. Icel., NW. Icel., SW. Icel. and S. Icel., see above, p. 5); a *(c)* placed after the name of the species indicates that it probably occurs in all parts of the coast.

Table 1. The Distribution of the Species along the coast.

		E. Icel.	N. Icel.	NW.Icel.	SW. Icel.	S. Icel.
	Rhodophyceæ.					
C	Bangia fusco-purpurea *(c)*	+	+	..	+	+
C	Porphyra umbilicalis *c*	+	+	+	+	+
B_2	P. miniata *c*	+	+	+	+	+
D	Porphyropsis coccinea	..	..	..	+	+
B_2	Conchocelis rosea *c*	+	+	+	+	+
C	Chantransia microscopica *(c)*	..	+	..	..	..
D	C. Alariæ	..	..	..	+	+
C	C. secundata *c*	+	+	+	+	+
B_2	C. virgatula *(c)*	..	..	+	+	..
E_1	Chondrus crispus	..	..	(+)	+	+
D	Gigartina mamillosa *(c)*	+	+	..	+	+
C	Ahnfeltia plicata	..	(+)	(+)	+	+
B_2	Phyllophora Brodiæi * interrupta	+	..	+	..	..
D	P. membranifolia	..	..	..	+	+
B_2	Actinococcus subcutaneus	+	..	+	..	..
A	Ceratocolax Hartzii	..	..	+	..	..
D	Cystoclonium purpurascens	..	+	+	+	+

Table 1. The Distribution of the Species along the coast (continued).

		E. Icel.	N. Icel.	NW.Icel.	SW.Icel.	S. Icel.
A	Turnerella Pennyi	+	+	..	..	..
B_2	Euthora cristata *c*	+	+	+	+	+
B_1	Rhodophyllis dichotoma *(c)*	+	+	+	+	..
B_2	Rhodymenia palmata *c*	+	+	+	+	+
E_1	Lomentaria clavellosa	..	..	..	..	+
D	L. rosea	..	..	..	..	+
E_1	Plocamium coccineum	..	..	..	..	+
B_1	Halosaccion ramentaceum *c*	+	+	+	+	+
D	Delesseria alata	..	..	..	+	+
A	D. Baerii * corymbosa	?	?	..	..	..
B_2	D. sinuosa *c*	+	+	+	+	+
D	D. sanguinea	(+)	..	..	+	+
E_2	Bonnemaisonia asparagoides	..	..	..	..	?
E_1	Pterosiphonia parasitica	..	..	..	..	+
D	Polysiphonia urceolata *c*	+	+	+	+	+
D	P. fastigiata	..	..	+	+	+
A	P. arctica	+	+	+	+	..
D	P. nigrescens	..	+	..	+	..
B_2	Rhodomela lycopodioides *c*	+	+	+	+	+
B_2	Odonthalia dentata *c*	+	+	+	+	+
D	Callithamnion Arbuscula	..	..	..	+	+
E_1	C. scopulorum	..	..	..	+	+
D	Plumaria elegans	..	..	..	+	+
B_2	Ptilota plumosa	..	+	+	+	+
B_1	P. pectinata	+	+	+	+	..
C	Antithamnion Plumula v. boreale *(c)*	+	+	+	+	..
D	A. floccosum *(c)*	+	..	..	+	+
D	Ceramium acanthonotum	..	..	..	+	+
D	C. Deslongchampii	..	..	..	+	..
D	C. fruticulosum	..	..	..	+	..
D	C. circinnatum	..	..	..	+	..
E_1	C. arborescens	..	+	+	+	..
D	C. atlanticum	..	..	..	+	+
C	C. rubrum *(c)*	..	+	+	+	+
C	Rhodochorton Rothii *c*	+	+	+	+	+
D	R. repens	..	..	..	..	+
D	R. minutum	..	..	..	+	..
B_1	R. penicilliforme *(c)*	+	+	+	+	..
C	R. membranaceum *(c)*	+	+	+	+	..
D	Dumontia filiformis *(c)*	+	..	..	+	+
D	Dilsea edulis	..	..	..	+	..
D	Petrocelis Hennedyi	..	+	+	+	+
A	Cruoria arctica	..	..	..	+	..
E_1	C. pellita	..	..	..	+	+
B_1	Peyssonellia Rosenvingii	+	+	+	+	..
D	Rhododermis parasitica	..	..	+	+	+

Table 1. The Distribution of the Species along the coast (continued).

		E. Icel.	N. Icel.	NW.Icel.	SW.Icel.	S. Icel.
B_2	Lithothamnion glaciale *(c)*	+	+	..	+	..
D	L. Ungeri *(c)*	+	+	+	..	..
B_1	L. tophiforme *(c)*	+	+	..	+	+
A	L. flavescens	+	..	..	..	..
A	L. foecundum	+	+	..	..	..
B_1	L. læve *c*	+	+	+	+	+
D	L. Lenormandi	..	..	..	+	..
D	Phymatolithon polymorphum	..	?	..	..	+
B_1	Clathromorphum compactum *c*	+	+	+	+	+
D	Lithophyllum Crouani	..	+	+	..	+
D	Dermatolithon macrocarpum	..	..	..	+	+
D	Corallina officinalis	..	+	+	+	+
C	Hildenbrandia rosea *c*	+	+	+	+	+
	Phæophyceæ.					
B_1	Lithoderma fatiscens *(c)*	+	+	+	+	..
D	Petroderma maculiforme	..	+	..	..	..
B_1	Ralfsia ovata *(c)*	..	+	..	+	..
B_2	R. clavata *(c)*	+	+	+	+	..
D	R. verrucosa *(c)*	+	+	..	+	..
B_1	R. deusta *(c)*	+	+	..	+	+
D	Myrionema vulgare	..	+	..	+	..
D	M. Corunnæ	..	..	..	..	+
B_1	M. globosum *(c)*	+	+	+	+	..
D	M. færoënse	..	..	..	+	..
B_1	M. Laminariæ *(c)*	..	..	..	+	..
D	Ascocyclus islandicus	..	+	..	..	..
D	Microsyphar Polysiphoniæ *(c)*	..	..	+	+	..
B_1	Streblonema æcidioides *(c)*	+	+	..	+	..
D	S. Stilophoræ v. cæspitosa *c*	+	+	+	+	+
C	Pylaiella littoralis *c*	+	+	+	+	+
B_2	Ectocarpus tomentosoides *c*	+	+	+	+	+
D	E. tomentosus	..	..	..	+	+
C	E. confervoides *c*	+	+	+	+	+
C	E. siliculosus *(c)*	..	+	..	+	..
D	E. penicillatus *(c)*	+	+	..	+	..
D	E. fasciculatus	..	..	..	+	+
D	E. Hinksiæ	..	..	..	..	+
B_2	Leptonema fasciculatum v. subcylindrica *(c)*	..	+	+	+	..
B_2	Elachista fucicola *c*	+	+	+	+	+
B_1	Sphacelaria britannica *(c)*	..	+	..	+	+
D	S. radicans *(c)*	+	+	..	+	+
D	S. olivacea	..	..	+	+	+
B_1	Chætopteris plumosa *(c)*	+	+	+	+	..
A	Omphalophyllum ulvaceum	+	..	..	..	..

Table 1. The Distribution of the Species along the coast (continued).

		E. Icel.	N. Icel.	NW. Icel.	SW. Icel.	S. Icel.
B_2	Punctaria plantaginea *(c)*	+	+	+	..	..
B_2	Litosiphon filiformis *(c)*	+	+	..	+	+
B_2	Isthmoplea sphærophora *(c)*	+	..	+	+	+
B_2	Stictyosiphon tortilis *(c)*	+	+	+	+	..
B_2	Phæostroma pustulosum *(c)*	+	..	+	+	..
C	Scytosiphon Lomentaria *c*	+	+	+	+	+
D	Phyllitis zosterifolia *(c)*	+	..	+	+	+
C	Ph. fascia *c*	+	+	+	+	+
B_1	Coilodesme bulligera	+	..	+	+	..
D	Dictyosiphon Ekmani	..	..	..	+	..
D	D. Mesogloia	..	+	..	..	..
D	D. Chordaria *(c)*	+	..	..	+	..
A	D. corymbosus	..	+	..	..	..
B_2	D. hippuroides *(c)*	..	+	+	+	+
B_2	D. foeniculaceus *(c)*	+	+	+	+	..
B_2	Desmarestia viridis *c*	+	+	+	+	+
B_2	D. aculeata *c*	+	+	+	+	+
E_1	D. ligulata	..	..	..	..	+
D	Castagnea virescens *(c)*	+	+	..	+	..
E_1	Leathesia difformis	..	+	..	+	..
B_2	Chordaria flagelliformis *c*	+	+	+	+	+
B_2	Chorda tomentosa *(c)*	+	+	..	+	..
B_2	C. Filum *(c)*	+	+	+	+	..
B_1	Saccorrhiza dermatodea *(c)*	+	+	+	+	..
D	Laminaria saccharina *c*	+	+	+	+	+
B_1	L. færoënsis	+	+	..	..	..
A	L. nigripes	+	..	..	..	..
B_1	L. digitata *c*	+	+	+	+	+
D	L. hyperborea *c*	+	+	+	+	+
B_1	Alaria Pylaii *c*	+	+	+	+	+
D	A. esculenta *c*	+	+	+	+	+
D	Fucus spiralis *(c)*	+	+	..	+	+
B_2	F. inflatus *c*	+	+	+	+	+
D	F. serratus	..	..	..	+	+
C	F. vesiculosus *c*	+	+	+	+	+
D	Pelvetia canaliculata	.	.	..	+	+
C	Ascophyllum nodosum *c*	+	+	+	+	+
	Chlorophyceæ.					
B_2	Chlorochytrium Cohnii *(c)*	..	..	..	+	..
B_2	C. inclusum *(c)*	+	+	+	+	..
B_2	C. dermatocolax *(c)*	..	+	..	+	..
B_1	C. Schmitzii *(c)*	..	..	..	+	..
D	Codiolum Petrocelidis	..	..	..	+	..
B_2	C. gregarium *(c)*	+	..	..	..	..
D	C. pusillum *(c)*	..	+	..	..	..

Table 1. The Distribution of the Species along the coast (continued).

		E. Icel.	N. Icel.	NW.Icel.	SW.Icel.	S. Icel.
B_2	Percursaria percursa *(c)*	..	..	..	+	..
D	Enteromorpha aureola	..	+	..	..	..
E_1	E. Linza	..	..	..	+	+
C	E. intestinalis *c*	+	+	+	+	+
C	E. clathrata *(c)*	+	+	..	+	+
A	Monostroma groenlandicum	+	+	+	..	..
B_2	M. Grevillei *c*	+	+	+	+	+
B_1	M. undulatum *c*	+	+	+	+	+
B_1	M. fuscum *c*	+	+	+	+	+
C	Ulva lactuca *(c)*	..	+	+	+	+
D	Prasiola polyrrhiza *(c)*	..	..	..	+	+
D	P. furfuracea *(c)*	+	+	..	+	..
D	P. stipitata *(c)*	+	+	..	+	+
B_1	Ulothrix consociata v. islandica	.	+	..	..	..
B_1	U. subflaccida *(c)*	+	+	..	..	..
B_1	U. pseudoflacca *(c)*	+	..	..	+	+
B_2	U. flacca *c*	+	+	+	+	+
B_2	Pseudendoclonium submarinum *(c)*	+	..	..	.	
D	Entoderma Wittrockii *(c)*	..	+	..	+	+
B_1	Acrochæte parasitica *(c)*	..	..	..	+	..
D	A. repens	..	..	+	..	..
B_2	Bolbocoleon piliferum *(c)*	+	+	+	..	..
B_2	Ulvella fucicola *(c)*	+	+	..	+	+
B_2	Pringsheimia scutata *(c)*	..	..	+	+	..
D	Ochlochæte ferox *(c)*	..	+	..	..	..
B_2	Urospora mirabilis *c*	+	+	+	+	+
B_1	U. Hartzii *(c)*	+	..	..	+	+
B_2	U. Wormskioldii *c*	+	+	+	+	+
C	Chætomorpha tortuosa *(c)*	+	+	..	+	..
B_2	C. Melagonium *c*	+	+	+	+	+
C	Rhizoclonium riparium *(c)*	+	+	..	+	..
B_2	Spongomorpha vernalis *(c)*	..	..	..	+	
D	Acrosiphonia albescens *c*	+	+	+	+	+
B_2	A. incurva *c*	+	+	+	+	+
B_1	A. hystrix *(c)*	+	+	+	+	..
D	A. flabelliformis	..	..	..	..	+
B_1	A. penicilliformis	+	..	..	..	..
B_2	Cladophora rupestris	..	..	+	+	+
B_2	C. hirta *(c)*	..	..	..	+	+
B_2	C. sericea *(c)*	..	+	..	+	+
D	C. glaucescens *(c)*	..	..	..	+	..
C	C. gracilis *(c)*	+	+	..	+	..
C	Gomontia polyrrhiza *(c)*	+	+	+	+	..
B_2	Ostreobium Queketti *(c)*	+	+	+	+	..

Table 1. The Distribution of the Species along the coast (continued).

		E. Icel.	N. Icel.	NW.Icel.	SW.Icel.	S. Icel.
	Cyanophyceæ.					
B_2	Pleurocapsa amethystea *c*	+	+	+	+	+
D	Plectonema norvegicum *(c)*	..	+	..	..	..
E	Phormidium autumnale *(c)*	+	..	..	..	..
C	Spirulina subsalsa *(c)*	..	+	..	+	..
C	Calothrix scopulorum *(c)*	+	+	..	..	..
C	Rivularia atra *(c)*	..	..	..	+	..

From Iceland (31, 14 and 57) there are published 76 species of red algæ, 67 species of brown, 51 of green and 6 af blue-green — 200 species in all. All of these, of course, are not equally common along the coast, and their habitats, as far as these are known, in the five districts into which the coast is divided, are given in the above table. That table shows that comparatively few species occur in all the coastal districts (in the table, such are indicated by the letter *c* placed after the name of the species). In all parts of the coast are found 15 species (20 %) of red algæ, 18 species (26.8 %) of brown, 10 species (19.6 %) of green and 1 species (16.6 %) of blue-green. Thus, of the 200 species there are 44 species (22 %) which are common to all the coastal districts.

If we take into consideration the fact that the great stretch of coast round the whole of Iceland is as yet far from accurately investigated, we may expect, after future investigations, not only that several more species will be found, but also that the distribution of the species in the different parts of the coast will prove to differ from what is at present stated to be the case. Therefore, in the above list of the distribution of the species along the coast I have placed a *(c)* after the name of those species which, as I surmise, are probably to be found in all parts of the coast. I base this supposition partly on the position of the habitats already known along the coast, and partly on the occurrence of the species in the adjacent floral districts, e. g. the Færöes and Greenland.

The mark *(c)* is subjoined to 14 species of red algæ, 29 species of brown, 32 species of green and to 5 species of blue-green. On adding to this the above-mentioned species which have the letter *c* subjoined we get 29 species (38 %) of red algæ, 47 species (70 %) of brown, 42 species (82 %) of green and 6 species (100 %) of blue-green. Thus, of the 200 species 124 prove to be common to all parts

of the coast. The percentage of each group is of the greatest importance, and for the sake of explicitness I have arranged these figures in a tabular form, both those which refer to *c* and those which refer to *c + (c)*.

Species common to all the coastal districts, given as percentages.

	Red algæ	Brown algæ	Green algæ	Blue-green algæ	All the groups collectively
c.....	20	27	19	17	22
c + (c)....	38	70	82	100	60

On considering these two series of figures it becomes evident that the figures given for *c + (c)* come nearer to the real facts, while those given for *c* merely indicate an incomplete knowledge of the coastal distribution of the species. The fact is that, where there is not a greater climatic difference between the different parts of the coast than is the case in Iceland, it may always be expected that, as regards the common species, the highest numbers will fall to the green and to the blue-green algæ; and where the hydrographic differences between the different parts of the coast are as pronounced as they are in Iceland, it is natural that the smallest number will fall to the red algæ, and just as naturally the brown algæ will in this respect be placed almost midway between the red and the green algæ.

Therefore, as regards the floristic difference between the different parts of the coast, particular stress is laid on the remaining 76 species. In the following table they are arranged according to their habitats. Under A, those species are given which either occur in E. or N. Iceland only, or are most common there, and thence are distributed southward along the north-west coast as far as SW. Iceland. Under B are given species which either have been found in S. or SW. Iceland only, or are most common there, and thence have a distribution northward along the north-west coast, many of them having, moreover, an eastward distribution along the north coast.

Table 2. The Distribution of the 76 species not common to all the coastal districts.

A	E. Icel.	N. Icel.	NW. Icel.	SW. Icel.	S. Icel.	E. Icel.	N. Icel.	NW. Icel.	SW. Icel.	S. Icel.	B
						..	..	..	..	+	1. Lomentaria clavellosa
						..	..	..	..	+	2. L. rosea
1. Lithothamnion flavescens	+	..	..	..	..	..	..	..	..	+	3. Plocamium coccineum

Table 2. The Distribution of the 76 species not common to all the coastal districts (continued).

A	E. Icel.	N. Icel.	NW.Icel.	SW.Icel.	S. Icel.	E. Icel.	N. Icel.	NW.Icel.	SW.Icel.	S. Icel.	B
2. Omphalophyllum ulvaceum	+	..	..	..	..	..	..	..	..	?	4. Bonnemaisonia asparagoides
						..	..	..	..	+	5. Pterosiphonia parasitica
3. Laminaria nigripes	+	..	..	..	..	..	..	..	..	+	6. Rhodochorton repens
						..	..	..	..	+	7. Phymatolithon polymorphum
4. Acrosiphonia penicilliformis	+	..	..	..	..	..	..	..	..	+	8. Myrionema Corunnæ
						..	.	..	..	+	9. Ectocarpus Hinksiæ
						..	..	..	..	+	10. Desmarestia ligulata
5. Delesseria Baerii	?	?	..	..	..	..	..	..	..	+	11. Acrosiphonia flabelliformis
						..	..	..	+	+	12. Porphyropsis coccinea
						..	..	..	+	+	13. Chantransia Alariæ
6. Turnerella Pennyi	+	+	..	..	..	..	..	..	+	+	14. Phyllophora membranifolia
7. Lithothamnion foecundum	+	+	..	..	..	..	..	..	+	+	15. Delesseria alata
						..	..	..	+	+	16. Callithamnion Arbuscula
						..	..	..	+	+	17. C. scopulorum
8. Laminaria færoënsis	+	+	..	..	..	..	..	..	+	+	18. Plumaria elegans
						..	..	..	+	+	19. Ceramium acanthonotum
						..	..	..	+	+	20. Cruoria pellita
9. Petroderma maculiforme.	..	+	..	..	..	..	..	..	+	+	21. Dermatolithon macrocarpum
10. Ascocyclus islandicus	..	+	..	..	..	..	..	..	+	+	22. Ectocarpus tomentosus
						..	..	..	+	+	23. E. fasciculatus
						..	..	..	+	+	24. Fucus serratus
11. Dictyosiphon Mesogloia	..	+	..	..	..	..	..	..	+	+	25. Pelvetia canaliculata
						..	..	..	+	+	26. Enteromorpha Linza
12. D. corymbosus	..	+	..	..	..	..	..	..	+	+	27. Ceramium Deslongchampii
						..	..	..	+	+	28. C. atlanticum
13. Enteromorpha aureola	..	+	..	..	..	..	..	..	+	..	29. C. fruticulosum
						..	..	..	+	..	30. C. circinnatum
						..	..	..	+	..	31. Rhodochorton minutum
14. Ulothrix consociata v. islandica	..	+	..	..	..	..	..	..	+	..	32. Dilsea edulis
						..	..	..	+	..	33. Lithothamnion Lenormandi
15. Monostroma groenlandicum	+	+	+	..	..	..	..	..	+	..	34. Myrionema færoënse
						..	..	..	+	..	35. Dictyosiphon Ekmani
						..	..	..	+	..	36. Codiolum Petrocelidis
16. Phyllophora Brodiæi v. interrupta	+	..	+	..	..	..	..	(+)	+	+	37. Chondrus crispus
						..	.	+	+	+	38. Polysiphonia fastigiata
						..	..	+	+	+	39. Rhododermis parasitica
						..	..	+	+	+	40. Sphacelaria olivacea
17. Actinococcus subcutaneus	+	..	+	..	..	..	..	+	+	+	41. Cladophora rupestris
						..	..	+	..	..	42. Acrochæte repens

Table 2. The Distribution of the 76 species not common to all the coastal districts (continued).

A	E. Icel.	N. Icel.	NW. Icel.	SW. Icel.	S. Icel.	E. Icel.	N. Icel.	NW. Icel.	SW. Icel.	S. Icel.	B
18. Ceratocolax Hartzii	..	..	+	..	..	..	+	+	+	..	43. Ceramium arborescens
						..	(+)	(+)	+	+	44. Ahnfeltia plicata
19. Polysiphonia arctica	+	+	+	+	..	..	+	+	+	+	45. Cystoclonium purpura-scens
20. Ptilota pectinata.....	+	+	+	+	..	..	+	+	+	+	46. Ptilota plumosa
						..	+	+	+	+	47. Petrocelis Hennedyi
21. Peyssonellia Rosenvingii.	+	+	+	+	..	..	+	+	+	+	48. Corallina officinalis
						..	+	+	..	+	49. Lithophyllum Crouani
22. Coilodesme bulligera	+	..	+	+	..	..	+	..	+	..	50. Polysiphonia nigrescens
						..	+	..	+	..	51. Myrionema vulgare
23. Cruoria arctica	..	..	..	+	..	..	+	..	+	..	52. Leathesia difformis
						(+)	..	..	+	+	53. Delesseria sanguinea
Total...	15	13	8	5	..	1	10	13	40	40	Total

To illustrate more distinctly how the species with a north-eastern distribution (A) and those with a south-western distribution (B) intermingle in N., NW. and SW. Iceland I subjoin the following figures taken from the preceding table: —

	E. Icel.	N. Icel.	NW. Icel.	SW. Icel.	S. Icel.	
	(1)	10	13	40	40	B
A	15	9 + 4	8	5	..	

Notes on the species. Of the 4 species (A, 1—4, Tab. 2) which have been found only in E. Iceland, Nos. 1 and 3 occurred in great abundance in several of the fjords, while *Omphalophyllum* was found only in Reyðarfjörður, where it occurred abundantly, and *Acrosiphonia* in one place only. *Delesseria Baerii*, I suppose (31, p. 140), has originated from either E. or N. Iceland.

Turnerella is most common in E. Iceland, and in addition to the habitat in N. Iceland which has been published (31, p. 135) has been found by B. Sæmundsson in Steingrímsfjörður in the most western part of the north coast; consequently it must have a wide distribution along this coast. With regard to *Lithothamnion foecundum* and *Laminaria færoensis* it must be assumed that they are more frequent in E. and N. Iceland than is known at present, and as the latter species occurs in the Færöes, it may well be expected to be met with on other parts of the coast of Iceland.

With respect to the 6 species (A, 9—14) which have been found only in N. Iceland, it cannot be assumed that they are confined to the north coast, and it is highly probable that they have a much wider distribution on both sides. *Dictyosiphon corymbosus* and *Ulothrix consociata v. islandica* must, however, be assumed to belong more closely to E. and N. Iceland.

As regards the 8 species (A, 15—22) which occur so far west or south as NW. Iceland or SW. Iceland, it must be supposed that their absence from N. Iceland (and E. Iceland *[Ceratocolax, Cruoria]*) is due merely to insufficient knowledge regarding their distribution. Of these species, those which extend to SW. Iceland have not been found, however, further south than in Breiðifjörður, with the exception of *Peyssonellia* which has been found in Faxaflói near Reykjavík.

Of the species given under A, Nos. 1—8, 12 and 14—23 must consequently be supposed to have an east-northward distribution along the coast of Iceland, while Nos. 9, 11 and 13 must be supposed to have some other principal distribution; one species (10) is endemic in the most western part of the north coast.

Under B, 53 species are recorded. Of these 10 have been found only in S. Iceland, the majority of these in the Vestmannaeyjar only; to these must be added *Bonnemaisonia* (31, p. 141) which I believe to have been found in S. Iceland. That is, 11 species in all, one of which, however, *Rhodochorton repens,* is endemic. 17 species have been found only in S. and SW. Iceland (B, 12—28) and 8 species in SW. Iceland only. Thus, there are in all 36 species which are known from S. and SW. Iceland only. 6 species (B, 37—42) have a more northern distribution, as they have been found in NW. Iceland. Consequently, there are 42 species which are known only from S. and W. Iceland (NW. Iceland included), but of these species there are two, *Cladophora rupestris* and *Codiolum Petrocelidis* which probably have a more northern distribution. 10 species (B, 43—52) which have principally a south-western distribution (the fact that some of them have not been found in NW., SW. and S. Iceland is probably due to insufficient knowledge regarding their distribution) have been found also in N. Iceland. But all these species do not reach eastward along the north coast to the same extent, *Ptilota plumosa* and *Corallina officinalis* have been found furthest east in the eastern part of the north coast; *Lithophyllum Crouani* and *Myrionema vulgare* in Eyjafjörður; *Ahnfeltia* and *Petrocelis* extend to

Skagafjörður; while *Cystoclonium, Polysiphonia nigrescens* and *Leathesia* do not extend further than the most western part of the north coast (the small fjords in Húnaflói). Only *Delesseria sanguinea* now remains; strictly speaking, this appears to belong to the south and south-west coast, but has on one occasion been found in E. Iceland, cast up on the shore. It did not appear to have come from a distance, and it probably grows there, though I did not come across it in the dredgings.

Thus all these 53 species have on the whole a southern and western distribution in Iceland.

The above shows that there is a large neutral territory where the species with a south-western and those with a north-eastern distribution meet and intermingle. This boundary area comprises almost the whole of the north coast, the north-west fjords and, to a certain extent, the northern part of the south-west of the country. (For further details see below under the Floristic Boundaries.)

THE COMPONENTS OF THE ALGAL FLORA.

At present 200 species of Marine Algæ are known from Iceland. In the plant-geographical groups established by Börgesen and myself (Börgesen and Jónsson, 14) these are distributed in the following manner. The definition of the groups is here reproduced almost literally from the publication mentioned.

A. The Arctic Group.

The species of this group belong to the arctic area of the sea. The southern limit of this area extends from the north and east of Norway southward to the south-east point of Iceland, where the boundary is sharply defined. From E. Iceland the boundary line extends to the north of Iceland between Iceland and Greenland, and then turns considerably southward to the North Atlantic coast of America. The flora of the boreal area of the Atlantic passes without any distinct limit into the arctic algal flora on both sides of the Atlantic. In Iceland the limit is distinct only at the south-east point whereas the boundary is very indistinct on the north-east part of the coast.

Some of the species of this group occur, but only rarely, south of the border-zone.

Rhodophyceæ.

Ceratocolax Hartzii.
Turnerella Pennyi.
Delesseria Baerii * corymbosa.
Polysiphonia arctica.
Cruoria arctica.
Lithothamnion flavescens.
L. foecundum.

Phæophyceæ.

Omphalophyllum ulvaceum.
Dictyosiphon corymbosus.
Laminaria nigripes.

Chlorophyceæ.

Monostroma groenlandicum.

B. The Subarctic Group.

Subdivision I.

The species of this subdivision are common in the Arctic Sea, and are rather common in the cold-boreal area of the Atlantic Ocean as far south as the Færöes and Nordland; some of them occur, although rarely, as far south as England.

Rhodophyceæ.

Rhodophyllis dichotoma.
Halosaccion ramentaceum.
Ptilota pectinata.
Rhodochorton penicilliforme.
Peyssonellia Rosenvingii.
Lithothamnion tophiforme.
L. læve.
Clathromorphum compactum.

Phæophyceæ.

Lithoderma fatiscens.
Ralfsia ovata.
R. deusta.
Myrionema globosum.
M. Laminariæ.
Streblonema æcidioides.
Sphacelaria britannica.
Chætopteris plumosa.
Coilodesme bulligera.
Saccorrhiza dermatodea.
Laminaria færöensis.
L. digitata.
Alaria Pylaii.

Chlorophyceæ.

Chlorochytrium Schmitzii.
Monostroma undulatum.
M. fuscum.
Ulothrix consociata v. islandica.
U. subflaccida.
U. pseudoflacca.
Acrochæte parasitica.
Urospora Hartzii.
Acrosiphonia hystrix.
A. penicilliforme.

Subdivision II.

This subdivision includes species, which are either common in the Arctic Sea and the North Atlantic from western France—England northward, or which, if not common, are at least all equally frequent.

Rhodophyceæ.

Porphyra miniata.
Conchocelis rosea.
Chantransia virgatula.
Phyllophora Brodiæi * interrupta.
Actinococcus subcutaneus.
Euthora cristata.
Rhodymenia palmata.
Delesseria sinuosa.
Rhodomela lycopodioides.
Odonthalia dentata.
Ptilota plumosa.
Lithothamnion glaciale.

Phæophyceæ.

Ralfsia clavata.
Ectocarpus tomentosoides.
Leptonema fasciculatum v. subcylindrica.
Elachista fucicola.
Punctaria plantaginea.
Litosiphon filiformis.
Isthmoplea sphærophora.
Stictyosiphon tortilis.
Phæostroma pustulosum.
Dictyosiphon hippuroides.
D. foeniculaceus.
Desmarestia viridis.
D. aculeata.
Chordaria flagelliformis.
Chorda tomentosa.
C. filum.
Fucus inflatus.

Chlorophyceæ.

Chlorochytrium Cohnii.
C. inclusum.
C. dermatocolax.
Codiolum gregarium.
Percursaria percursa.
Monostroma Grevillei.
Ulothrix flacca.
Pseudendoclonium submarinum.
Bolbocoleon piliferum.
Ulvella fucicola.
Pringsheimia scutata.
Urospora mirabilis.
U. Wormskioldii.
Chætomorpha Melagonium.
Spongomorpha vernalis.
Acrosiphonia incurva.
Cladophora rupestris.
C. hirta.
C. sericea.
Ostreobium Queketti.

Cyanophyceæ.

Pleurocapsa amethystea.

C. The Boreal-Arctic Group.

The species of this group are common in the Arctic Sea and the boreal area of the Atlantic at least as far south as the Atlantic coast of North Africa; probably some of them have a far greater southern distribution. Some of them might possibly be considered cosmopolitan.

Rhodophyceæ.

Bangia fuscopurpurea.
Porphyra umbilicalis.
Chantransia microscopica.
C. secundata.
Ahnfeltia plicata.
Antihamnion Plumula v. boreale.
Ceramium rubrum.
Rhodochorton Rothii.
R. membranaceum.
Hildenbrandia rosea.

Phæophyceæ.

Pylaiella littoralis.
Ectocarpus confervoides.
E. siliculosus.
Scytosiphon Lomentaria.
Phyllitis fascia.
Fucus vesiculosus.
Ascophyllum nodosum.

Chlorophyceæ.

Enteromorpha intestinalis.
E. clathrata.
Ulva lactuca.
Chætomorpha tortuosa.
Rhizoclonium riparium.
Cladophora gracilis.
Gomontia polyrrhiza.

Cyanophyceæ.

Spirulina subsalsa.
Calothrix scopulorum.
Rivularia atra.

D. The Cold-Boreal Group.

The species of this group have their area of distribution from western France—England northward to S. Iceland, the Færöes and Nordland—Finmark. Some few species have occasionally been found in the Arctic Sea, especially in the White Sea and the Murman Sea, and some few reach as far south as the Mediterranean and North Africa.

Rhodophyceæ.

Porphyropsis coccinea.
Chantransia Alariæ.
Gigartina mamillosa.
Phyllophora membranifolia.
Cystoclonium purpurascens.
Lomentaria rosea.
Delesseria alata.
D. sanguinea.
Polysiphonia urceolata.
P. fastigiata.
P. nigrescens.
Callithamnion Arbuscula.
Plumaria elegans.
Antithamnion floccosum.
Ceramium acanthonotum.
C. Deslongchampii.
Ceramium fruticulosum.
C. circinnatum.
C. altanticum.
Rhodochorton repens.
R. minutum.
Dumontia filiformis.
Dilsea edulis.
Petrocelis Hennedyi.
Rhododermis parasitica.
Lithothamnion Ungeri.
L. Lenormandi.
Phymatolithon polymorphum.
Lithophyllum Crouani.
Dermatolithon macrocarpum.
Corallina officinalis.

Phæophyceæ.

Petroderma maculiforme.
Ralfsia verrucosa.
Myrionema vulgare.
M. Corunnæ.
M. færöense.
Ascocyclus islandicus.
Microsyphar Polysiphoniæ.
Streblonema Stilophoræ v. cæspitosa.
Ectocarpus tomentosus.
E. penicillatus.

Ectocarpus fasciculatus.
E. Hinksiæ.
Sphacelaria radicans.
S. olivacea.
Phyllitis zosterifolia.
Dictyosiphon Ekmani.
D. Mesogloia.
D. Chordaria.
Castagnea virescens.
Laminaria saccharina.
L. hyperborea.
Fucus spiralis.
F. serratus.
Pelvetia canaliculata.
Alaria esculenta.

Chlorophyceæ.

Codiolum Petrocelidis.
C. pusillum.
Enteromorpha aureola.
Prasiola polyrrhiza.
P. furfuracea
P. stipitata.
Entoderma Wittrockii.
Acrochæte repens.
Ochlochæte ferox.
Acrosiphonia albescens.
A. flabelliformis.
Cladophora glaucescens.

Cyanophyceæ.

Plectonema norvegicum.

E. The Warm-Boreal Group.

The majority of the species referred to this group extend at least as far south as the Mediterranean and the Atlantic coast of North Africa. According to the different distribution northward the group is divided into three parts of which only the one reaches as far north as S. Iceland.

1. Species extending as far north as S. Iceland, the Færöes and Northern Norway, and at least as far south as the Mediterranean and North Africa.

Rhodophyceæ.

Chondrus crispus.
Lomentaria clavellosa.
Plocamium coccineum.
Bonnemaisonia asparagoides.
Pterosiphonia parasitica.
Callithamnion scopulorum.
Ceramium arborescens.
Cruoria pellita.

Phæophyceæ.

Desmarestia ligulata.
Leathesia difformis.

Chlorophyceæ.

Enteromorpha Linza.

Cyanophyceæ.

Phormidium autumnale.

According to the above the number of species in the groups is as follows: —

	Rhodo-phyceæ	Phæo-phyceæ	Chloro-phyceæ	Cyano-phyceæ			
1. The arctic group.....	7	3	1	»	= 11	species	(5.5 %)
2. The subarctic group:							
Subdivision I.....	8	13	10	»	= 31	—	(15.5 %)
3. The subarctic group:							
Subdivision II.....	12	17	20	1	= 50	—	(25.0 %)
4. The boreal-arctic group	10	7	7	3	= 27	—	(13.5 %)
5. The cold-boreal group.	31	25	12	1	= 69	—	(34.5 %)
6. The warm-boreal group	8	2	1	1	= 12	—	(6.0 %)
	76	67	51	6			

If we divide the six groups into two parts, A: the first three groups, and B: the last three[1] groups, we obtain the following figures: —

A, 92 species (46 %) and B, 108 species (54 %).

The floral district must therefore be determined as boreal, because more than half of the species belong to the last three groups. Of these groups the cold-boreal is the most important because its species form 64 % of the total number of species (108) in all three groups. This floral district has not, however, a purely boreal character, as the subarctic group is rich in species and gives a rather high percentage (41 %). The floral district, then, is characterized to a very high degree by a boreal element, and next by a subarctic element.

If we consider only the red and the brown algæ, 143 species in all, the cold-boreal character is a little more strongly pronounced than the subarctic. The figures are: — Arctic 10 species (7 %), subarctic 50 species (35 %), boreal-arctic 17 species (12 %), cold-boreal 56 species (39 %) and warm-boreal 10 species (7 %). The first three groups have 60 species (42 %), the last three 78 species (58 %).

If we compare the five divisions of the coast with respect to the number of species in the different groups, we obtain the figures given in Tables 3, 4.

If, for instance, we select the red and the brown algæ (Table 4) as a basis, then the difference which exists in the different parts of the coast is very evident. In E. Iceland the arctic group contains the greatest number of species, and this number — if we follow the divisions of the coast in the order of the tables — decreases

[1] The boreal-arctic group is included in the boreal groups, as its species, though common in the arctic district, have a far larger area of distribution outside this.

Table 3. Red algæ, Brown algæ, Green algæ, Blue-green algæ collectively.

	E. Icel.		N. Icel.		NW. Icel.		SW. Icel.		S. Icel.	
	Number of species	%	Number of species	%	Number of species	%	Number of species	%	Number of species	%
Arctic group.....	8	7	5	4	3	3	2	1	»	»
Subarctic group I.....	25	22	24	20	16	17	27	18	12	11
Subarctic group II.....	38	34	37	30	39	41	44	28	28	26
Boreal arctic group....	20	18	26	21	16	17	23	15	16	15
Cold-boreal group.....	20	18	29	24	18	20	53	34	43	39
Warm-boreal group....	1	c. 1	2	c. 1	2	c. 2	6	4	9	9
Total...	112		123		94		155		108	

Table 4. Red and Brown algæ collectively.

	E. Icel.		N. Icel.		NW. Icel.		SW. Icel.		S. Icel.	
	Number of species	%	Number of species	%	Number of species	%	Number of species	%	Number of species	%
Arctic group.....	7	9	4	5	2	3	2	2	»	»
Subarctic group I.....	18	23	19	22	13	18	20	17	8	10
Subarctic group II.....	25	31	24	28	27	37	26	23	17	20
Boreal arctic group....	13	16	17	19	13	18	16	14	13	15
Cold-boreal group.....	17	21	21	24	16	22	46	40	38	45
Warm-boreal group....	»	»	2	2	2	2	5	4	8	10
Total...	80		87		73		115		84	

uniformly in the other parts of the coast, and is reduced to 0 in S. Iceland. In E., N., NW. and SW. Iceland the number of the species in the subarctic group I is practically identical in proportion to the number of species, taken as a whole, in these parts of the coast; S. Iceland has a distinctly smaller number, only 10 %. The subarctic group II is represented most abundantly in NW. Iceland; E. and N. Iceland come next; but S. and SW. Iceland have a considerably lower percentage (about 20 %). The percentage in the boreal-arctic group is practically identical in all parts of the coast. The cold-boreal group presents almost the same percentage in E., N. and NW. Iceland, while the percentage in the group in

SW. and S. Iceland is almost double this. The warm-boreal group is not represented in E. Iceland, and only with extreme rarity (1 species) in N. and NW. Iceland. SW. Iceland has only 4 species, while S. Iceland has 8 (10 %).

There is a very great similarity between S. Iceland and SW. Iceland, if the arctic group in SW. Iceland is excluded; on the other hand, the difference is greatest between E. Iceland and S. Iceland, as is shown by the following figures: —

	East Iceland	South Iceland
Arctic group	9 %	0 %
Subarctic groups	54 %	30 %
Boreal-arctic group	16 %	15 %
Cold-boreal group	21 %	45 %
Warm-boreal group	0 %	10 %

If we assume that the species marked (c) (Table 1) are to be considered as common to all parts of the coast (see above), the distribution of the 76 not-common species becomes decisive with reference to the floristic difference between the parts of the coast. In the following table, therefore, it is shown how these 76 species are arranged in the six plant-geographical groups of algæ.

Table 5. Group-division of the 76 not-common species (see Table 2).

A	E. Icel.	N. Icel.	NW. Icel.	SW. Icel.	S. Icel.	B
	..	..	..	..	..	Arctic group.
Arctic group	8	5	3	2	..	
	..	..	..	..	..	Subarctic group I.
Subarctic group I	5	4	3	3	..	
	..	1	2	2	2	Subarctic group II.
Subarctic group II	2	..	2	..	..	
	..	1	1	1	1	Boreal-arctic group.
Boreal-arctic group	..	..	..	..	..	
	1	6	8	31	28	Cold-boreal group.
Cold-boreal group	..	4	..	..	..	
	..	2	2	6	9	Warm-boreal group.
Warm-boreal group	..	..	..	..	..	
	1	10	13	40	40	Total number of species
Total number of species	15	9 + 4	8	5	..	
	16	23	21	45	40	

The figures in this table show what has been already shown by those which I have given in Tables 3 and 4; but the arctic

element in E. Iceland and the boreal element in S. and SW. Iceland are much more sharply defined; and this is natural, as the species assumed to be common are omitted. Even if we consider only the known distribution of the species, in its entirety (see Table 1), the distribution of the here-mentioned 76 species will still be the most essential reason for the floristic difference between the parts of the coast.

The species assumed to be common are 124 (see above). Of these none are arctic, 25 belong to the subarctic group I, 46 to the subarctic group II, 26 are boreal-arctic, 26 cold-boreal, and one *(Phormidium autumale)* is warm-boreal. Of the 76 not-common species, 11 are arctic, 6 belong to the subarctic group I, 4 to the subarctic group II, one *(Ahnfeltia plicata)* is boreal-arctic, 43 are cold-boreal and 11 warm-boreal. If we add together the numbers representing the species of the corresponding groups as regards the 124 species assumed to be common and the 76 not-common species (Table 5), and compare with Table 3, we find that the species are more numerous in each district, but that the percentages are almost the same.

If the groups are divided in two parts, A and B (see above) so that A includes the arctic and subarctic groups, and B the three other groups, the following figures are obtained (see Table 4): —

	E. Icel.	N. Icel.	NW. Icel.	SW. Icel.	S. Icel.
A	50 (63 %)	47 (54 %)	42 (58 %)	48 (42 %)	25 (30 %)
B	30 (37 %)	40 (46 %)	31 (42 %)	67 (58 %)	59 (70 %)

The arctic group is poorly represented in all the districts of the coast (see Table 4) and therefore the figures mentioned above under A apply chiefly to the subarctic group; the floral districts of E. Iceland, N. Iceland and NW. Iceland are thus subarctic. E. Iceland is subarctic to a greater extent than N. and NW. Iceland. SW. Iceland is a boreal floral district with a very considerable subarctic element, and thus resembles the coasts of Iceland taken as a whole (see above). S. Iceland is a boreal district with a slightly subarctic element.

Floristic Boundaries.

The mixed character of the flora in N. and NW. Iceland has been alluded to several times in the foregoing pages, and is clearly seen from the tables given, as, for example, Tables 2 and 5. Here,

neither, is any distinct boundary found between the boreal and subarctic floral districts, and the north and north-west of the country must, strictly speaking, be considered a large boundary-area, a view which accords well, also, with the hydrographic conditions. Here, the boreal, subarctic and arctic species intermingle.

At the south-eastern point of Iceland there is, on the other hand, a rather distinct hydrographic boundary along the stretch from Vestrahorn to Eystrahorn (or Lónsheiði). The greater part of this coast is sandy, and difficult of access for the investigation of the algal vegetation. From my own observations I can only say that Berufjörður, the most southerly point in E. Iceland which I have examined with regard to its algal vegetation, has a cold-water flora, and that the Vestmannaeyjar, the most easterly locality on the south coast which I have examined for the same purpose, have a warm-water flora. The boundary must lie between them, and I conclude, especially from the hydrographic conditions and the distribution of the Plankton-associations, that it is situated just on the stretch of coast already mentioned. Ove Paulsen (55 and 56) has given valuable information respecting this boundary, and it is evident from his investigations that the boundary varies to a slight extent, the facts being that in May-June it has been found in the vicinity of Eystrahorn (see 55, map I), but in July-August at Vestrahorn (see 55, map II). If algæ grow on this stretch of coast, one may conclude that there exists a mixed flora resembling that of N. and NW. Iceland. Whether boreal species can be carried to E. Iceland in this manner is at present not easy to say with certainty, yet it seems to me that the occurrence of *Dumontia filiformis* and *Delesseria sanguinea*, both of which are absent in N. and NW. Iceland, can be most easily explained in this way.

IV. COMPARISON WITH NEIGHBOURING FLORAL DISTRICTS.

In Table 6[1] is given a survey of the plant-geographical distribution of red and brown algæ collectively, in certain subarctic and boreal floral districts. These are so arranged that those floras with the largest arctic element stand furthest to the left. The arctic and subarctic percentages decrease while the boreal percentage increases to the right. The boreal-arctic group is practically similar everywhere, which is also natural according to the geographical distribution of the group. The warm-boreal group is not represented in the subarctic floras, and the arctic group is quite infinitesimal in SW. Iceland and Nordland, and is entirely absent from S. Iceland and the Færöes. In regard to species, the cold-boreal group is extremely poor in East Greenland and Spitzbergen, somewhat richer in West Greenland and considerably richer in E. Iceland.

By grouping the species, as is done above (cf. Börgesen and Jónsson, 14), the character of the floral districts can be determined according to those groups which are richest in species. Thus, I characterize a group as subarctic when more than half of its species are reckoned to the subarctic group. In a similar manner a district is boreal when more than half of its species belong to the boreal groups (bor. arct., cold-bor., and warm-bor.).

Similarly, in an arctic district the species belonging to the arctic group must constitute more than half of the number of species belonging to the district, and, in addition to the subarctic group, only the boreal-arctic will be represented. Of the floral districts mentioned by Börgesen and Jónsson (14) none are arctic according

[1] With the exception of Iceland the numbers of the species of red and brown algæ are taken from Börgesen and Jónsson l. c. (14, p. 22). In regard to East Greenland the numbers are corrected according to Rosenvinge (64), and to West Greenland two species have been added: *Ectocarpus maritimus* and *Chantransia collopoda*.

to the definition here employed. The Siberian Sea, however, comes nearest to it. From here 23 species are known (14), of which 9 (39 %) are arctic, 11 (48 %) subarctic and 3 (13 %) boreal-arctic. This district is at the boundary between arctic and subarctic. Regarded superficially it may appear strange that none of the districts are arctic, but on closer inspection this is easily understood, the reason being that some of the districts (14) are too large and consequently acquire a mixed character. In this respect I shall merely point out, for instance, that both Spitzbergen and East Greenland (and probably West Greenland) ought to be divided into two districts.

As already mentioned, none of the districts recorded in Table 6 is arctic. East Greenland, Spitzbergen and West Greenland have almost the same percentage as regards the arctic species (Table 6), and as this percentage is rather high in proportion to that of the boreal species, these districts could be termed arctic-subarctic, in contradistinction to E. Iceland where the arctic percentage is four times less than the percentage of the boreal species. The boreal districts recorded here (Table 6, p. 70) should, strictly speaking, be called cold-boreal.

If we call the first three groups (in Table 6) A and the three last B the percentages will be as follows: —

	E. Greenl.	Spitzb.	W.Greenl.	E. Icel.	Finm.	SW. Icel.	S. Icel.	Fær.	Nordl.
A.....	81	77	72	63	46	42	30	29	27
B.....	19	23	28	37	54	58	70	71	73

As the table shows, SW. Iceland agrees most closely with Finmark, while S. Iceland and the Færöes are nearly alike, as Börgesen (12, p. 804) also supposes.

If we take Iceland as a whole, we get 143 species (red and brown algæ collectively), 10 (7 %) arctic, 21 (15 %) subarctic (subdivision I), 29 (20 %) subarctic (subdivision II), 17 (12 %) boreal-arctic, 56 (39 %) cold-boreal and 10 (7 %) warm-boreal. These figures are almost the same as those given for Finmark (see Table 6) and differ, essentially from the figures given for SW. Iceland, only by the higher percentage of arctic and warm-boreal species. If, on the other hand, we take the first three groups collectively and the three last groups in a similar manner, we obtain the same percentages as for SW. Iceland. On combining different parts of the coast, as for instance, E. Iceland and N. Iceland, we get almost the

Table 6. Distribution in groups of Red and Brown algæ collectively in certain Subarctic and Boreal floral districts.

	East Greenl.		Spitz-bergen		West Greenl.[1]		E. Icel.		Finmark		SW. Icel.		S. Icel.		Færöes[1]		Nordland	
	Number of species	%	Number of species	%	Number of species	%	Number of species	%	Number of species	%	Number of species	%	Number of species	%	Number of species	%	Number of species	%
Arctic group	15	18	10	17	20	18	7	9	7	6	2	2	..	..	..	..	1	1
Subarctic group I	26	30	14	23	27	26	18	23	21	17	20	17	8	10	14	9	12	10
Subarctic group II	28	33	22	37	31	28	25	31	29	23	26	23	17	20	31	20	20	16
Subarctic group I + II	54	63	36	60	58	54	43	54	50	40	46	40	25	30	45	29	32	26
Boreal-arctic group	12	14	9	15	17	16	13	16	18	14	16	14	13	15	17	11	16	13
Cold-boreal group	4	5	5	8	13	12	17	21	45	36	46	40	38	45	75	47	61	49
Warm-boreal group	..	..	..	..	..	..	..	..	5	4	5	4	8	10	20	13	13	11
Total...	85		60		108		80		125		115		84		157		123	
	Subarctic								Boreal									

[1] According to Petersen (57) 2 species of *Ceramium* (*C. Areschoughii* [assigned to the subarctic group II] and *C. septentrionale* [assigned to the arctic group]) have here been added to West Greenland. To the Færöes have been added *Ceramium Boergesenii* and *Ceramium atlanticum,* both of which I assign to the cold-boreal group.

same figures as for E. Iceland, and on combining NW., SW. and S. Iceland we get almost the same figures as for SW. Iceland. E. Iceland and N. Iceland have 101 species of red and brown algæ collectively. Of these 8 (8 %) are arctic, 20 (20 %) subarctic (subdivision I), 28 (27 %) subarctic (subdivision II), 17 (17 %) boreal-arctic, 26 (26 %) cold-boreal and 2 (2 %) warm-boreal. NW., SW. and S. Iceland have 131 species of red and brown algæ collectively. Of these 3 (2 %) are arctic, 20 (15 %) subarctic (subdivision I), 29 (22 %) subarctic (subdivision II), 16 (12 %) boreal-arctic, 53 (41 %) cold-boreal and 10 (8 %) warm-boreal.

As regards the components of the flora, both Iceland taken as a whole, and SW. Iceland resemble Finmark; S. Iceland resembles the Færöes and Nordland, and E. Iceland resembles the White Sea.[1]

It is evidently not due to chance that the resemblance of the floral districts happens thus. The situation of Iceland just south of and at the boundary between the arctic and the cold-boreal districts corresponds exactly with the situation of Nordland—Finmark—White Sea in relation to this boundary. Iceland and the White Sea are at the boundary itself, and in Finmark it certainly will be possible to distinguish parts of the coast with a similar mixed flora as in N. and NW. Iceland; the southern part of Finmark will then be something like SW. Iceland, while S. Iceland, as already mentioned, corresponds with Nordland.

This comparison shows only the relation between the quantity of the species of the floral districts within the different groups, but gives no information as to how far the species are common to all those districts. Then it remains to be investigated how many species Iceland has in common with the other districts. At the present time a comparison of the floras will, however, scarcely give any satisfactory results, because all the districts in question are not equally well-known. By future investigations a greater number of species will unquestionably be found in the majority of the floral districts, and the quantity of the species will thus be altered, but the relation between the number of the species of the different groups will, however, undoubtedly remain unaltered.

[1] According to Börgesen and Jónsson (14) 52 species are known from the White Sea, of which 3 (6 %) are arctic, 10 (19 %) subarctic (subdivision I), 19 (37 %) subarctic (subdivision II), 8 (15 %) boreal-arctic and 12 (23 %) cold-boreal. The subarctic species constitute 56 % of the entire number of species and the character of the flora is consequently subarctic in the same degree as that of E. Iceland.

If we compare S. Iceland and the Færöes with regard to common species, the following figures are obtained: —

South Iceland 84 species[1]		The Færöes 157 species
not common	common	not common
10 (6 %)	74 (44 %)	83 (50 %)

Here it should be noted that S. Iceland is so very little known that one is scarcely justified in comparing it with such a well investigated district as the Færöes. Many of the species which in this respect are peculiar to the Færöes will certainly be found in S. Iceland and, at any rate, 32 of them are known from other parts of Iceland, principally from SW. Iceland.

If we choose a larger district of the coast of Iceland, for instance, the boreal district (S. Iceland and SW. Iceland) for comparison with the Færöes, the following figures will be obtained: —

S. and SW. Iceland 126 species		The Færöes 157 species
not common	common	not common
25 (14 %)	101 (55 %)	56 (31 %)

On comparing Iceland with the Færöes we obtain the following figures: —

Iceland 143 species		The Færöes 157 species
not common	common	not common
37 (19 %)	106 (55 %)	51 (26 %)

The 37 species which grow in Iceland and are absent from the Færöes are the following: —

†Chantransia microscopica.
Ceratocolax Hartzii.
Turnerella Pennyi.
Delesseria Baerii.
Bonnemaisonia asparagoides.[2]
Polysiphonia arctica.
Ceramium Deslongchampii.
C. fruticulosum.
C. circinnatum.
C. arborescens.
†Rhodochorton minutum.
†R. repens.
†Dilsea edulis.
†Petrocelis Hennedyi.
Cruoria arctica.
†Peyssonellia Rosenvingii.
†Rhododermis parasitica.
Lithothamnion flavescens.
L. foecundum.
†L. tophiforme.
†L. Ungeri.
†Ralfsia ovata.
R. deusta.
†Myrionema Laminariæ
†Ascocyclus islandicus.
†Ectocarpus penicillatus.

[1] These and the following figures apply to red and brown algæ collectively.

[2] I attach no importance to the fact of this species having occurred in Iceland, as it has not yet been found again.

†Sphacelaria radicans.
†S. olivacea.
Omphalophyllum ulvaceum.
†Phæostroma pustulosum.
Coilodesme bulligera.
†Dictyosiphon Mesogloia.
†Dictyosiphon Chordaria.
D. corymbosus.
Saccorrhiza dermatodea.
Laminaria nigripes.
†Fucus serratus.

Which of these species may be found in the Færöes is not easy to decide (cf. also Börgesen, 12, p. 795). But it does not appear altogether improbable that 19 species (marked with a † before the name) could occur there.

The 51 Færöese species which are not found in Iceland are the following: —

†Erythrotrichia ceramicola.
†Porphyra leucosticta.
†Chantransia effloresccns.
†C. Daviesii.
Choreocolax Polysiphoniæ.
†Harveyella mirabilis.
Callophyllis laciniata.
Callocolax neglectus.
Sterrocolax decipiens.
†Lomentaria articulata.
Nitophyllum laceratum.
Laurencia pinnatifida.
Polysiphonia violacea.
†P. Brodiæi.
†P. elongata.
P. atrorubescens.
Rhodomela subfusca.
Griffithsia setacea.
†Callithamnion polyspermum.
†C. corymbosum.
C. granulatum.
†Ceramium Boergesenii.
Rhodochorton seiriolanum.
†Furcellaria fastigiata.
†Polyides rotundus.
†Cruoriella Dubyi.
†Rhododermis elegans.
Phymatolithon lævigatum.
Lithophyllum incrustans.
L. hapalidioides.
†Sorapion Kjellmani.
†Myrionema foecundum.
†M. speciosum.
†Chilionema reptans.
Microsyphar Zosteræ.
Ectocarpus velutinus.
†E. lucifugus.
E. dasycarpus.
E. granulosus.
Elachista scutulata.
Sphacelaria cæspitula.
S. furcigera.
†S. cirrhosa.
Cladostephus spongiosus.
Desmotrichum undulatum.
Punctaria latifolia.
†Asperococcus echinatus.
†Litosiphon Laminariæ.
†Phæostroma parasiticum.
†Himanthalia lorea.
†Halidrys siliquosa.

Possibly many of these species, perhaps almost half of them, are to be found in S. and SW. Iceland. The 26 species marked with a † before the name may possibly be found in Iceland, though with many of them this is doubtful.

If it should appear from further investigations that some of the species considered not common to the Færöes and Iceland are common to them, it should not be assumed from this that the floristic

resemblance is increased, as it is highly probable that other species which are not common would be simultaneously found.

From the coast of Norway I select Finmark for comparison with Iceland, which comparison gives the following figures: —

Iceland 143 species		Finmark 125 species
not common	common	not common
45 (26 %)	98 (58 %)	27 (16 %)

A comparison between Finmark and SW. Iceland gives the following figures: —

SW. Iceland 115 species		Finmark 125 species
not common	common	not common
29 (19 %)	86 (56 %)	39 (25 %)

The following are the 45 species which are found in Iceland and are absent from Finmark: —

1 Porphyropsis coccinea.
2 Chantransia Alariæ.
3 Phyllophora membranifolia.
4 Ceratocolax Hartzii.
5 Lomentaria rosea.
6 L. clavellosa.
7 Plocamium coccineum.
8 Delesseria Baerii.
9 Bonnemaisonia asparagoides.
10 Pterosiphonia parasitica.
11 Callithamnion Arbuscula.
12 Ceramium acanthonotum.
13 C. fruticulosum.
14 C. arborescens.
15 C. atlanticum.
16 Rhodochorton minutum.
17 R. repens.
18 Dilsea edulis.
19 Petrocelis Hennedyi.
20 Cruoria arctica.
21 C. pellita.
22 Rhododermis parasitica.
23 Petroderma maculiforme.
24 Ralfsia ovata.
25 R. clavata.
26 R. verrucosa.
27 Myrionema Lamimariæ.
28 M. Corunnæ.
29 M. globosum.
30 M. færöense.
31 Ascocyclus islandicus.
32 Microsyphar Polysiphoniæ.
33 Ectocarpus Stilophoræ.
34 E. tomentosoides.
35 E. tomentosus.
36 E. Hinksiæ.
37 Sphacelaria radicans.
38 S. olivacea.
39 Omphalophyllum ulvaceum.
40 Litosiphon filiformis.
41 Phæostroma pustulosum.
42 Phyllitis zosterifolia.
43 Dictyosiphon Mesogloia.
44 Desmarestia ligulata.
45 Laminaria færöensis.

Of these species ten (Nos. 3, 6, 7, 10, 11, 12, 18, 21, 26 and 35) are known from Nordland and therefore might possibly be found also in Finmark. Furthermore, nine of the species (Nos. 2, 5, 9, 25, 33, 34, 35, 40, 44) are known from West Norway, and the majority of these will also be found, without doubt, in Nordland and Fin-

mark. Of the remaining 23 species the greater number will certainly be found in Finmark. But I think it less probable that *Omphalophyllum ulvaceum* and *Laminaria fœröensis* are to be met with there, while one can form no opinion as to whether the endemic Icelandic species (17 and 31) exist in Finmark, as their distribution outside Iceland is unknown. On the other hand I think it somewhat probable that the Icelandic-Færöese species *Myrionema fœröense* may occur in Finmark.

The 27 species, which are present in Finmark and absent from Iceland, are the following: —

Chantransia efflorescens.
C. Daviesii.
Harveyella mirabilis.
Polysiphonia elongata.
Spermothamnion Turneri.
Furcellaria fastigiata.
Polyides rotundus.
Petrocelis Middendorfii.
Phymatolithon investiens.
Lithothamnion intermedium.
L. fornicatum.
Lithoderma lignicola.
Myrionema foecundum.
Chilionema reptans.
Ectocarpus terminalis.
E. nanus.
E. ovatus.
Myriotrichia filiformis.
Sphacelaria racemosa.
S. cirrhosa.
Phæosaccion Collinsii.
Asperococcus echinatus.
Delamarea attenuata.
Dictyosiphon hispidus.
Laminaria Agardhii.
Haplospora globosa.
Halidrys siliquosa.

The majority of these species may be expected to occur on the coasts of Iceland, but there is less probability of *Laminaria Agardhii* being met with there.

If we turn to E. Iceland and compare this with the White Sea we obtain the following figures: —

E. Iceland 80 species		White Sea 52 species
not common	common	not common
43 (45 %)	37 (39 %)	15 (16 %)

The floristic similarity is somewhat considerable, and ten of the species peculiar to the White Sea are known from other parts of the coast of Iceland. These ten species are *Dilsea edulis, Cystoclonium purpurascens, Polysiphonia nigrescens, Delesseria alata, Ptilota plumosa, Lithothamnion Lenormandi, Corallina officinalis, Dictyosiphon hippuroides, Fucus serratus,* and *Pelvetia canaliculata.*

Of these species, however, only an extremely small number can be expected to occur in E. Iceland.

The five species present in the White Sea and entirely absent from Iceland are: —

Chantransia efflorescens.
Furcellaria fastigiata.
Polyides rotundus.
Sphacelaria racemosa.
Laminaria Agardhii.

With the exception of *Laminaria Agardhii* all these species certainly may be met with on the coasts of Iceland, but in E. Iceland one can scarcely expect to find others than *Chantransia efflorescens* and *Sphacelaria racemosa.*

If we compare Iceland and E. Iceland with West Greenland and East Greenland we get the following figures: —

Iceland 143 species		West Greenland 108 species
not common	common	not common
62 (36 %)	81 (48 %)	27 (16 %)
Iceland 143 species		East Greenland 85 species
not common	common	not common
79 (48 %)	64 (39 %)	21 (13 %)
E. Iceland 80 species		West Greenland 108 species
not common	common	not common
11 (9 %)	69 (58 %)	39 (33 %)
E. Iceland 80 species		East Greenland 85 species
not common	common	not common
23 (21 %)	57 (53 %)	28 (26 %)

The species present in Iceland and absent from West Greenland are the following: —

Porphyropsis coccinea.
Chantransia Alariæ.
Phyllophora membranifolia.
Ahnfeltia plicata.
Chondrus crispus.
Gigartina mamillosa.
Cystoclonium purpurascens.
Lomentaria rosea.
L. clavellosa.
Plocamium coccineum.
Delesseria alata.
D. sangvinea.
Bonnemaisonia asparagoides.
Polysiphonia fastigiata.
P. nigrescens.
Pterosiphonia parasitica.
Odonthalia dentata.
Callithamnion scopulorum.
C. Arbuscula.
Plumaria elegans.
Ptilota plumosa.
Ceramium acanthonotum.
C. Deslongchampii.
C. fruticulosum.
C. circinnatum.
C. arborescens.
C. atlanticum.
Rhodochorton minutum.
R. repens.
Dumontia filiformis.
Dilsea edulis.
Petrocelis Hennedyi.
Cruoria pellita.
Rhododermis parasitica.
Phymatolithon polymorphum.
Lithothamnion Lenormandi.
L. flavescens.
L. Ungeri.
Lithophyllum Crouani.
Dermatolithon macrocarpum.

Corallina officinalis.
Petroderma maculiforme.
Myrionema Laminariæ (in E. Greenl.)
M. vulgare.
M. Corunnæ.
M. færöense.
Ascocyclus islandicus.
Ectocarpus tomentosus.
E. fasciculatus.
E. Hinksiæ.
Sphacelaria olivacea.
Dictyosiphon Ekmani.
D. Mesogloia.
Desmarestia ligulata.
Leathesia difformis.
Laminaria saccharina (in E. Greenl.)
L. færöensis.
L. hyperborea.
Alaria esculenta (in E. Greenl.)
Fucus spiralis.
F. serratus.
Pelvetia canaliculata.

Of the 57 species here mentioned three are found in East Greenland; viz. *Myrionema Laminariæ, Laminaria saccharina* and *Alaria esculenta.* It is most probable that none of these 57 species will be met with in West Greenland, with the exception, perhaps, of some of the *Myrionema*-species.

There are 74 species absent from East Greenland which are found in Iceland. Of these, 54 species have already been mentioned (see above), and to these must be added 20 species which are absent from East Greenland but present in West Greenland and Iceland. These species are the following: —

Bangia fuscopurpurea.
Porphyra umbilicalis.
Chantransia secundata.
C. virgatula.
Polysiphonia urceolata.
Antithamnion floccosum.
Ceramium rubrum.
Ralfsia ovata.
R. verrucosa.
Microsyphar Polysiphoniæ.
Ectocarpus Stilophoræ.
E. tomentosoides.
E. penicillatus.
Sphacelaria radicans.
Litosiphon filiformis.
Phyllitis zosterifolia.
Dictyosiphon Chordaria.
D. corymbosus.
D. hippuroides.
Castagnea virescens.

It seems most probable that these 20 species are to be met with in East Greenland.

The 11 species present in E. Iceland and absent from West Greenland are included in the above-mentioned figure. They are: —

Gigartina mamillosa.
Delesseria sangvinea.
Odonthalia dentata.
Dumontia filiformis.
Lithothamnion flavescens.
L. Ungeri.
Laminaria saccharina (in E. Greenl.)
L. færöensis.
L. hyperborea.
Alaria esculenta (in E. Greenl.)
Fucus spiralis.

The 23 species present in E. Iceland and absent from East Greenland have also been already recorded. With the addition of the 9 of the above-mentioned species they are the following: —

Bangia fuscopurpurea.
Porphyra umbilicalis.
Chantransia secundata.
Polysiphonia urceolata.
Antithamnion floccosum.
Ralfsia verrucosa.
Ectocarpus Stilophoræ.
Ectocarpus tomentosoides.
E. penicillatus.
Sphacelaria radicans.
Litosiphon filiformis.
Phyllitis zosterifolia.
Dictyosiphon Chordaria.
Castagnea virescens.

These species might possibly also be found in East Greenland, as they are already known from West Greenland (see above), and in that case there could be only 9 E. Iceland-species which were not known from East Greenland.

In West Greenland there are 27 species which are not found in Iceland. These are: —

Ø Harveyella mirabilis.
Callymenia sangvinea.
Delesseria Montagnei.
Polysiphonia elongata.
Ceramium Areschoughii.
C. septentrionale.
Ø Rhododermis elegans.
Lithothamnion intermedium.
Chantransia collopoda.
Ø Sorapion Kjellmani.
Ectocarpus Pringsheimii.
Ø E. ovatus.
Ø E. pycnocarpus.
Ø E. maritimus.
Ø Sphacelaria racemosa.
Phæosaccion Collinsii.
Ø Symphyocarpus strangulans.
Kjellmania subcontinua.
Coelocladia arctica.
Ø Delamarea attenuata.
Dictyosiphon hispidus.
Myriocladia callitricha.
Ø Laminaria solidungula.
Ø L. longicruris.
L. cuneifolia.
Ø L. groenlandica.
Ø Agarum Turneri.

Of these species 13 (with Ø prefixed) are found in East Greenland.

In East Greenland 21 species are found which are not known from Iceland. In addition to the 13 above-mentioned species, they are the following: —

Chantransia efflorescens.
Dilsea integra.
Petrocelis polygyna.
Cruoriopsis hyperborea.
Ectocarpus helophorus.
Haplospora globosa.
Punctaria glacialis.
Myrionema foecundum.

The greater number of the West Greenland and East Greenland species here mentioned will probably be met with in Iceland, especially on the north and east coasts. It is less likely, however, that the following species will be found in Iceland: — *Callymenia sanguinea, Delesseria Montagnei, Dilsea integra, Petrocelis polygyna, Laminaria solidungula, L. cuneifolia, L. groenlandica* and *Agarum Turneri.*

According to the above comparisons Iceland most nearly resembles Finmark, and next to that place the Færöes; the resemblance to West

Greenland is rather less, and to East Greenland is least of all, as the following figures show: —

	common	not common
Iceland—Finmark	58 %	42 %
Iceland—the Færöes	55 %	45 %
Iceland—West Greenland	48 %	52 %
Iceland—East Greenland	39 %	61 %

S. Iceland is too little known to be compared with other districts, as has already been emphasized above. The resemblance to the Færöes will certainly prove to be much greater than is shown by the figures now known.

	common	not common
S. Iceland—the Færöes	44 %	56 %
S. and SW. Iceland—the Færöes .	55 %	45 %

S. Iceland and SW. Iceland together resemble the Færöes to the same degree as do the coasts of Iceland taken as a whole. The fact that S. Iceland least resembles the Færöes is merely due to a deficient knowledge of its coasts.

As regards SW. Iceland—Finmark the percentage of species common to both places is 56 and that of not common 44. Thus, the resemblance is somewhat less than that between Iceland and Finmark.

If we now turn to E. Iceland we obtain the following figures: —

	common	not common
E. Iceland—West Greenland.....	58 %	42 %
E. Iceland—East Greenland.....	53 %	47 %
E. Iceland—White Sea	39 %	61 %

E. Iceland has thus the greatest floristic resemblance to West Greenland, resembles East Greenland somewhat less and the White Sea least of all, although the floral districts of E. Iceland and the White Sea resemble each other most closely when the species are grouped according to geographical distribution (see above).

V. THE VERTICAL DISTRIBUTION OF THE SPECIES.

If we walk along the beach at low-tide we see a belt laid bare, the breadth of which varies according to the degrees of declivity of the coast and according to the tides — that is according to whether it is spring-tide or neap-tide. At spring-tide the belt is broad and at neap-tide narrow. The low-water mark of neap-tide divides the belt laid bare into two parts, an upper part which is laid bare during every low-tide and a lower part which is laid bare only at and about spring-tide. The upper part, between the upper limit of growth of the algal vegetation and the low-water mark of neap-tide, which almost coincides with the lower edge of the *Fucaceæ*-belt, I call the Upper Littoral Zone. The lower part, from the lower edge of the *Fucaceæ*-belt to the usual[1] low-water mark of spring-tide, I call the Lower Littoral Zone. Below low-water mark of spring-tide begins the vegetation which is constantly submerged. That the vegetation of the lower littoral zone is closely connected with that in the upper part of the constantly-submerged zone is natural and will be discussed subsequently.

In the following table a dash (—) denotes a habitat (depth) in which the species has been found many times, and a dot (·) one in which it has been found either once or comparatively rarely.

Table 7. The Vertical Distribution of the Species.

	Littoral zone		Depth (metre)																
	upper	lower	1—5	6—10	11—15	16—20	21—25	26—30	31—35	36—40	41—45	46—50	51—55	56—60	61—65	65—70	88		
Rhodophyceæ.																			
l Bangia fuscopurpurea	—																		
sl Porphyra miniata		—	—	—															

[1] No notice is taken of the extraordinarily low ebb-tides which occasionally occur and by which large *Laminariæ* are often exposed.

Table 7. The Vertical Distribution of the Species (continued).

	Littoral zone		Depth (metre)															
	upper	lower	1—5	6—10	11—15	16—20	21—25	26—30	31—35	36—40	41—45	46—50	51—55	56—60	61—65	66—70	88
l Porphyra umbilicalis	—	—															
s Porphyropsis coccinea				·		—											
s Conchocelis rosea	·			·	·	·	·	·	·								
sl Chantransia microscopica	·	·															
s C. Alariæ				—													
sl C. secundata	·	—															
sl C. virgatula	·	—															
sl Chondrus crispus		—	·														
sl Gigartina mamillosa	·	—	—	·	·	·											
sl Ahnfeltia plicata		—	—	·	·	·											
s Phyllophora Brodiæi v. interrupta				·	·	·	·	·									
sl P. membranifolia		—															
s Actinococcus subcutaneus						·	·	·									
s Ceratocolax Hartzii								·									
sl Cystoclonium purpurascens		—	·														
s Turnerella Pennyi			·		·	·	—	—	—	—	—	·	·	·			
s Euthora cristata			·	—	—	—	—	—	—	—	·						
s Rhodophyllis dichotoma			·	—	—	—	—	—	—	—							
sl Rhodymenia palmata		—	—	—	·	·											
s Lomentaria clavellosa			·	—	—	—	—	—	—	—							
s L. rosea			·	—	—	—	—	—	—	—							
s Plocamium coccineum		·	·	·	—	—	·	·	·	·							
sl Halosaccion ramentaceum		—	—	—													
s Delesseria alata		—	—	—	—	—	·	·	·	·							
D. Baerii * corymbosa																	
s D. sinuosa			·	—	—	—	—	—	—	—	—	·	·	·			
s D. sanguinea			—	—	—	—	—	·	·	·							
Bonnemaisonia asparagoides																	
s Polysiphonia urceolata	·	—	—	—	—	·	·	·	·	·							
l P. fastigiata	—																
s P. arctica			·	·	—	—	—	—	—	—	—	—	—	·	·		
sl P. nigrescens		·			·												
s Pterosiphonia parasitica						·	·	·									
sl Rhodomela lycopodioides		—	—	—													
s Odonthalia dentata			·	—	—	—	—	—	·								
sl Callithamnion Arbuscula	·	—															
sl C. scopulorum	·	—															
sl Plumaria elegans	·	—															
s Ptilota plumosa			·	—	—	—	—	—	—	—	—	—	·	·	·		
s P. pectinata			·	—	—	—	—	—	·	·	·						
s Antithamnion Plumula v. boreale				—	·	·	·										
sl A. floccosum		—	—	—													
sl Ceramium Deslongchampii	·																

Table 7. The Vertical Distribution of the Species (continued).

	Littoral zone		Depth (metre)															
	upper	lower	1—5	6—10	11—15	16—20	21—25	26—30	31—35	36—40	41—45	46—50	51—55	56—60	61—65	66—70	88
sl Ceramium fruticulosum		·															
sl C. circinnatum	·																
sl C. arborescens		·															
sl C. atlanticum	·	·															
sl C. rubrum	·	—	—	—	·	·											
sl C. acanthonotum		—															
l Rhodochorton Rothii	—		·	—													
s R. repens			·														
sl R. minutum		·															
s R. penicilliforme		·	·	—		·	·										
s R. membranaceum		·	·	—		·	·										
sl Dumontia filiformis		—															
sl Dilsea edulis		—															
s Petrocelis Hennedyi		—	—	—	·	·	·	·									
s Cruoria arctica		·			·	·											
sl C. pellita		·															
s Peyssonellia Rosenvingii			·	—	—	·	·										
s Rhododermis parasitica			·	—	—												
s Lithothamnion glaciale			—	—	—	—	—	·	·	·	·	·	·	·	·		
s L. Ungeri					·	—	—	—	·	·							
s L. tophiforme					·	·	·	—	—	·	·	·	·	·	·	·	·
s L. flavescens						·	·	·	·	·							
s L. foecundum						·	·										
s L. læve		—	—	—	—	·	·	·	·	·							·
s L. Lenormandi			·														
sl Phymatolithon polymorphum		·	—														
s Clathromorphum compactum		—	—	—	—	·	·	·	·								
s Lithophyllum Crouani			·	·	·												
s Dermatolithon macrocarpum			—	—	—	—											
sl Corallina officinalis		—		·													
l Hildenbrandia rosea	—	—	—														
Phæophyceæ.																	
s Lithoderma fatiscens		—	—	—	—	·	·										
l Petroderma maculiforme	·																
s Ralfsia ovata			·	·													
l R. clavata	—																
l R. verrucosa	·	·															
sl R. deusta	·	—															
sl Myrionema vulgare		·															
s M. Corunnæ			·	·													
sl M. globosum	·	—															
sl M. færöense		·															

Table 7. The Vertical Distribution of the Species (continued).

	Littoral zone		Depth (metre)															
	upper	lower	1—5	6—10	11—15	16—20	21—25	26—30	31—35	36—40	41—45	46—50	51—55	56—60	61—65	66—70	88
sl Myrionema Laminariæ		·															
sl Ascocyclus islandicus		·															
sl Microsyphar Polysiphoniæ		·	·														
s Streblonema æcidioides			·	·													
sl S. Stilophoræ v. cæspitosa		—															
l Pylaiella litoralis	—	—	—	—	·												
s Ectocarpus tomentosoides			—	—	—	—											
l E. tomentosus	—																
sl E. confervoides		—	—	—	·												
sl E. siliculosus		—	—	—	·												
sl E. penicillatus		—	—	—													
sl E. fasciculatus		—	—	—													
s E. Hinksiæ			—	—													
sl Leptonema fasciculatum v. subcylindrica		·	—	—													
l Elachista fucicola	—	—	·	·													
l Sphacelaria britannica	—																
sl S. radicans		·	—	—	—												
s S. olivacea			·	·													
s Chætopteris plumosa			—		·	·											
s Omphalophyllum ulvaceum							—	—	—	—	·	·	·				
sl Punctaria plantaginea		—															
sl Litosiphon filiformis			—	—													
l Isthmoplea sphærophora	—	—	—	—													
sl Stictyosiphon tortilis		—	·	·	·												
sl Phæostroma pustulosum		·	·	·													
sl Scytosiphon Lomentaria	·	—															
sl Phyllitis zosterifolia		—	·	·													
sl P. fascia		—															
sl Coilodesme bulligera	·	—															
sl Dictyosiphon Ekmani		·															
sl D. Mesogloia		·															
sl D. Chordaria		·	·														
sl D. corymbosus		·	·														
sl D. hippuroides		·															
sl D. fœniculaceus		—	·	·													
s Desmarestia viridis			·	·	·	—	—	—	—	—	·	·	·	·			
s D. aculeata			·	—	—	—	—	—	—	—	·	·	·	·			
s D. ligulata						·?											
sl Castagnea virescens		·	·	·													
sl Leathesia difformis		—															
sl Chordaria flagelliformis		—	·	·													
s Chorda tomentosa		·	—	—	—	—	·	·									

Table 7. The Vertical Distribution of the Species (continued).

	Littoral zone		Depth (metre)														
	upper	lower	1—5	6—10	11—15	16—20	21—25	26—30	31—35	36—40	41—45	46—50	51—55	56—60	61—65	66—70	88
s Chorda Filum		·	—	—	—	—											
s Saccorrhiza dermatodea			—	—	—	—	—	·									
s Laminaria saccharina			·	—	—	—	—	—	·								
s L. færöensis						—	—	—									
s L. nigripes			—	—	—	—											
s L. digitata			·	—	—	—	—	—	·								
s L. hyperborea			·	—	—	—	—	—	—	·							
s Alaria Pylaii			·	—	—	—	—	—	—	·	·						
s A. esculenta			·	—	—	—	—	—	·	·							
l Fucus spiralis	—																
l F. inflatus	—																
l F. serratus	—																
l F. vesiculosus	—																
l Pelvetia canaliculata	—																
l Ascophyllum nodosum	—																
Chlorophyceæ.																	
l Chlorochytrium Cohnii	·																
s C. inclusum		·	·					·									
sl C. dermatocolax	·	·	·														
l C. Schmitzii	·																
sl Codiolum Petrocelidis		·	—	—													
l C. gregarium	·				·												
l C. pusillum	·																
l Percursaria percursa	·																
l Enteromorpha aureola	·																
l E. Linza	—																
l E. intestinalis	—																
l E. clathrata	—																
l Monostroma groenlandicum	—																
sl M. Grevillei		—	—	—													
sl M. undulatum		—	—	—	·	·	·	·									
sl M. fuscum		—	—	—													
sl Ulva lactuca		—	—	—													
l Prasiola polyrrhiza	·																
l P. furfuracea	·																
l P. stipitata	—																
l Ulothrix consociata v. islandica	—																
l U. subflaccida	·																
l U. pseudoflacca	—																
l U. flacca	—	·	·	·													
l Pseudendoclonium submarinum	·																
sl Entoderma Wittrockii	·	—															

Table 7. The Vertical Distribution of the Species (continued).

	Littoral zone		Depth (metre)															
	upper	lower	1—5	6—10	11—15	16—20	21—25	26—30	31—35	36—40	41—45	46—50	51—55	56—60	61—65	66—70	88
l Acrochæte parasitica	·																
sl A. repens		?	?														
sl Bolbocoleon piliferum	·	—															
l Ulvella fucicola	·		·														
sl Pringsheimia scutata		·	·	·													
l Ochlochæte ferox	·																
l Urospora mirabilis	—																
l U. Hartzii	—																
sl U. Wormskioldii		—	·														
l Chætomorpha tortuosum	—																
sl C. Melagonium		—	—	—													
l Rhizoclonium riparium	—																
sl Spongomorpha vernalis		—	·														
l Acrosiphonia albescens	—																
sl A. incurva		—	·														
sl A. hystrix		—	—	—			·	·									
l A. flabelliformis	·																
l A. penicilliformis	·																
l Cladophora rupestris	—							·									
l C. hirta	·																
l C. sericea	—																
l C. glaucescens	·																
l C. gracilis	·																
s Gomontia polyrrhiza				·	·	·	·	·	·	·					·		
s Ostreobium Queketti				·	·	·	·	·	·	·	·						
Cyanophyceæ.																	
l Pleurocapsa amethystea	—																
l Plectonema norvegicum	·																
l Phormidium autumnale	·																
l Spirulina subsalsa	·																
l Calothrix scopulorum	—																
l Rivularia atra	·																
Fungi.																	
Dothidella Laminariæ				—	—	—	—	·	·								

A. Upper Littoral Zone.

The preceding table shows that 18 species of *Rhodophyceæ*, 18 species of *Phæophyceæ*, 36 species of *Chlorophyceæ* and 6 species of *Cyanophyceæ* grow in the upper littoral zone; that is, 78 species

in all. Of these species some are common and others rare; some are found exclusively in the upper littoral zone and others extend further downwards. In order to show this more distinctly, each group will here be dealt with separately and in detail.

Rhodophyceæ. Of the 18 species mentioned 5 are common, and the remaining 13 rarer. The following are the commonly distributed species: *Bangia fuscopurpurea*, which is found exclusively in the upper littoral zone; *Porphyra umbilicalis* which is found also in the lower littoral zone; *Polysiphonia fastigiata* which occurs exclusively on *Ascophyllum nodosum* in the upper littoral zone; *Rhodochorton Rothii* which extends to a depth of 10 metres, and *Hildenbrandia rosea* which extends to a depth of 5 metres. The three first-named species are common in places exposed to the light in the littoral zone; *Rhodochorton* and *Hildenbrandia*, on the other hand, occur most frequently as an undergrowth, or in shady clefts *(Rhodochorton)*, and at the bottom of pools *(Hildenbrandia)*. These two species are met with more rarely in places exposed to the light. The 13 species which occur in the upper littoral zone, but which must be called somewhat rare, are there shade-loving, and are then found either as an undergrowth or in shady clefts and depressions. Some are epiphytes, and are then protected against desiccation by the host-plant. The greater number of these 13 species are common in the lower littoral zone, and the 3 *Ceramium*-species which are recorded exclusively from the upper littoral zone may doubtless be expected to occur also in the lower littoral zone. *Conchocelis* does not occur in the lower littoral zone but is found at a depth of 6—35 metres.

Phæophyceæ. Of brown algæ the *Fucaceæ* play the most important rôle. The species are few in number, but are of social growth, and occur in such quantities that they comprise by far the greater portion of the bulk of the plants in the upper littoral zone. Of the 18 species mentioned above, 12 are commonly distributed, and 6 are more rare, in the upper littoral zone. Of the 12 common species, 9 are found exclusively in the upper littoral zone, viz., 6 species of *Fucaceæ, Sphacelaria britannica, Ectocarpus tomentosus* and *Ralfsia clavata; Pylaiella littoralis, Elachista fucicola* and *Isthmoplea,* on the other hand, range to a depth of about 10 metres. Of the rarer species, *Petroderma* is found exclusively in the upper littoral zone, *Ralfsia verrucosa* is most frequent in the upper littoral zone, but is also met with in the lower littoral zone, as an epi-

phyte; the remaining 4 species are common in the lower littoral zone, and occur in pools in the upper littoral zone, consequently they cannot, strictly speaking, be reckoned as belonging to the upper littoral zone.

Chlorophyceæ. In the table, 36 species of green algæ are mentioned from the upper littoral zone. Of these, 15 are characterized as common and 21 as rarer. 31 species are recorded exclusively from the upper littoral zone; 2 species, *Entoderma* and *Bolbocoleon* are more frequent in the lower littoral zone; one species *Chlorochytrium dermatocolax* is as frequent in the lower littoral zone as in the upper littoral zone, one species *Ulothrix flacca*, which must be considered a decidedly littoral species, grows to a depth of about 10 metres. *Ulvella fucicola* also grows to a depth of 5 metres, but must nevertheless be considered littoral. In addition to these 36 species, others may be found in the upper littoral zone, which have a more downward extension (e. g. *Monostroma Grevillei* var. *arctica*, *M. fuscum*, *Acrosiphonia incurva*, and others), but they generally keep to the pools.

Cyanophyceæ. All the species hitherto found (6) grow in the upper littoral zone.

The species which are recorded from the upper littoral zone may be put into two divisions. The one comprises the species which are common in the upper littoral zone and are adapted to growth in places exposed to the light and the wind during the period of exposure; these species, then, might be termed strictly littoral. The other division comprises species which are common in the lower littoral zone or extend even further downwards. The greater number of these species does not occur in the open littoral zone, but is found as an undergrowth or in shady clefts, or in pools. The real home of these species is lower down than in the upper littoral zone, and for this reason they can scarcely be designated littoral species.

According to the above, there are in all 58 strictly littoral species: *Rhodophyceæ* 5 species, *Phæophyceæ* 14 species, *Chlorophyceæ* 33 species and *Cyanophyceæ* 6 species.

The upper littoral zone is thus essentially characterized by a paucity of species of red algæ, by many species of green algæ and by a preponderance of *Fucaceæ*. The number of the species of brown algæ is of less importance; it is three times as large as that of the red algæ and about half as large as that of the green algæ.

If we reckon, in percentages, the number of species of each group of the total number of species in the upper littoral zone we obtain the following figures. The strictly littoral species (58 in all) are indicated by *a*, the other species (20 in all) not strictly littoral are indicated by *b*, but no attention is paid to those species which may be found in the upper littoral zone and appear to grow by preference in pools.

	Rhodophyceæ	Phæophyceæ	Chlorophyceæ	Cyanophyceæ
a	5 (9 %)	14 (24 %)	33 (57 %)	6 (10 %)
a + *b*	18 (23 %)	18 (23 %)	36 (46 %)	6 (8 %)

So far as the abundance of species is concerned I lay special stress on the red algæ, green algæ and blue-green algæ. It would be confusing, especially as regards the red algæ, to reckon the *b*-species as strictly littoral, nor can this be done, because they are not adapted for life in the open littoral zone. As regards the brown and green algæ, on the other hand, it is of no essential importance whether the *b*-species are included or not, as they are so few in number.

If we calculate how great a proportion the strictly littoral species form of the combined number of each group we obtain the following figures: —

	Rhodophyceæ	Phæophyceæ	Chlorophyceæ	Cyanophyceæ
Species known at present from Iceland	76	67	51	6
Strictly littoral species	5 (6.6 %)	14 (20.9 %)	33 (64.7 %)	6 (100 %)
a + *b* (see above)	18 (23.7 %)	18 (26.8 %)	36 (70.6 %)	6 (100 %)

B. The Lower Littoral Zone and the Belt below down to a depth of about 10 metres.

1. The Lower Littoral Zone. From this are recorded 93 species in all (Table 7), viz. 39 *Rhodophyceæ*, 37 *Phæophyceæ* and 17 *Chlorophyceæ*. Of these 93 species, the upper and lower littoral zones have 15 species in common (8 red, 5 brown, 2 green) which do not extend further downwards; the greater number of these belong, strictly speaking, to the lower littoral zone, as, in the upper littoral zone, they usually occur in pools or very shady spots. 19 species (8 red, 11 brown) have been found only in the lower littoral zone; but the majority of them probably occur also below the limit of low-tide, and, in any case, some have their area of distribution

close to this limit; 6 species (1 red, 3 brown, 2 green) have their area of distribution in the upper and lower littoral zones, and to a depth of 10 metres, these species are mentioned under the Upper Littoral Zone, and there, 5 of them are reckoned as littoral. 35 species (10 red, 15 brown, 10 green) grow in the lower littoral zone, and to a depth of about 10 metres. They appear to be about as common in the lower littoral zone as in the belt between the limit of low-tide and the depth mentioned. 18 species (12 red, 3 brown, 3 green) grow in the lower littoral zone, and to a depth of more than 10 metres; these belong to the species which have a lower downward range, 15 of them have their uppermost limit in the lower littoral zone, and 3 of them in the upper littoral zone.

The species characteristic of the lower littoral zone are especially the 19 species which are found there only, and the 35 species which extend to a depth of about 10 metres, for some of these (e. g. *Rhodymenia* and *Halosaccion*), by occurring in masses, often characterize large portions of the lower littoral zone.

2. The Belt down to a depth of about 10 metres. In the table 103 species are recorded from this belt. Of these, two occur also in the upper littoral zone, and have been previously mentioned *(Rhodochorton Rothii* and *Hildenbrandia),* 6 occur also in the upper and lower littoral zones and are mentioned above, 35 occur also in the lower littoral zone (see under this heading); while 9 species are found only at this depth, but of these some may be presumed to extend further downwards and some may possibly occur in the lower littoral zone. 19 species extend downwards, with their uppermost limit in the upper and lower littoral zones, as, for example, *Conchocelis rosea* which occurs in the upper littoral zone and is absent from the lower littoral zone, besides the 18 species mentioned under the Lower Littoral Zone. 32 species with a downward range have their uppermost limit at a depth of about 10 metres.

Besides the 9 species which are found only in this belt, it is especially the 35 species which this belt has in common with the lower littoral zone which characterize the belt, as some of them — those mentioned under the Lower Littoral Zone — by occurring in masses often characterize large portions of the bottom.

By comparison it can easily be seen that the lower littoral zone is much more closely related to this belt than to the upper littoral zone, which, amongst other things, is evident from the great

number of red algæ in the lower littoral zone. This can be distinctly seen from the following figures: —

Upper Littoral Zone		Lower Littoral Zone
58 species (*a*)		93 species
not common	common	not common
51 (35.42 %)	7 (4.86 %)	86 (59.72 %)

Upper Littoral Zone		Lower Littoral Zone
78 species (*a* + *b*)		93 species
not common	common	not common
54 (36.73 %)	24 (16.33 %)	69 (46.94 %)

Lower Littoral Zone		From the limit of low-tide to a depth of about 10 m. 103 species.
93 species		
not common	common	not common
34 (24.82 %)	59 (43.06 %)	44 (32.12 %)

The figures show that the upper littoral zone is very unlike the lower littoral zone, especially if only the species which are characteristic of the latter, or which occur in the open littoral zone *(a)*, are taken into consideration, which is most correct, as the shade-loving species in the upper littoral zone must be regarded as stragglers from associations lower down. As previously mentioned, the lower littoral zone bears the greatest resemblance to the belt which exists lower down (to a depth of about 10 metres).

The species which have their lower limit of growth at a depth of about 10 metres and which are commonly distributed in the lower littoral zone I designate semi-littoral because they are found both laid bare during low-tide in the lower littoral zone and constantly submerged in the belt below; as these species especially characterize the lower littoral zone and the belt below to a depth of about 10 metres I designate this area the semi-littoral zone. It must not be concluded, however, that semi-littoral vegetation covers the bottom everywhere down to a depth of 10 metres; below the limit of low-tide the semi-littoral vegetation appears rather to consist of stragglers from the lower littoral zone into the *Laminaria*-belt. Thus the semi-littoral zone is situated between the *Fucus*-belt and the *Laminaria*-belt. The species which specially occur in the semi-littoral zone I designate on the whole as semi-littoral, also those which are found in the lower littoral zone and are not found below the limit of low-tide; they will probably be found also below this limit. Species which are common in the lower littoral zone and are rare in the

upper littoral zone, but not known below the limit of low-tide I have also designated semi-littoral as they might be expected to grow lower down.[1]

C. The Sublittoral Species.

These species play the principal rôle in the sublittoral vegetation. This may be characterized in a somewhat similar manner as the vegetation of the upper littoral zone, although conversely as regards red and green algæ, viz. by a large number of red algæ and an extremely small number of green algæ and by the occurrence of a mass of *Laminariaceæ*. In Table 7, these species are marked with an s before the name. Their number is shown by the following figures: —

	Species		
	Littoral	Semi-littoral	Sublittoral
Red[2]	5	30	39
Brown	14	31	22
Green	33	15	3
Blue-green	6		
Total	58	76	64

From a comparison of the number of species of the sublittoral zone with that of the littoral and semi-littoral zones it is seen that it is smallest in the littoral zone, somewhat larger in the sublittoral zone and considerably larger in the semi-littoral zone. Species of green algæ occur most abundantly in the littoral zone, and their number is infinitesimal in the sublittoral zone. Red algæ are most numerous in the sublittoral zone and very scarce in the littoral zone. The brown algæ are more evenly distributed in the different zones, yet they are richest in species in the semi-littoral zone. The blue-green algæ are found exclusively in the littoral zone.

In the semi-littoral zone the large brown algæ do not occur in masses like, for example, the belt of *Fucus* in the upper littoral

[1] As regards the majority of the species (see Table 7) it is easy to decide whether they are littoral, semi-littoral or sublittoral, but there are some species, nevertheless, which it is difficult to refer definitely to any one of the three zones mentioned, and therefore it is sometimes a matter of opinion whether they should be reckoned in the one or the other. By perusing the table these species are easily detected.

[2] Two species, *Delesseria Baerii* and *Bonnemaisonia asparagoides* are not included as their habitat is unknown to me (see 31, pp. 140, 141).

zone and the belt of *Laminaria* in the sublittoral zone. This is possibly the reason why the semi-littoral zone is richest in species.

In Table 7, 64 species are recorded as sublittoral. Besides these, semi-littoral species occur in this zone, especially as epiphytes, or, more rarely, as undergrowth. 12 species, almost all semi-littoral, which extend to a greater depth than 10 metres are mentioned in the table. In addition, about 14 species can be regarded as epiphytic, particularly in the upper part of the sublittoral zone. The sublittoral vegetation is thus composed of 64 sublittoral species and of about 26 semi-littoral species, or about 90 species in all.

Lower Limits of Growth.

As far as the lower limit of growth is concerned the species which are found below low-tide must be dealt with collectively. In the following table, which shows the lower limits of growth, all the depths at which species have been known to occur have been, as a rule, taken into consideration, and thus the table does not indicate the depth of their general distribution or the depth at which they form associations (see under Vegetation). In the table, 2 red algæ are omitted, as I have no further knowledge regarding their habitats (31, pp. 140, 141). These species are *Delesseria Baerii* and *Bonnemaisonia asparagoides*. As regards the green algæ it must also be stated that I have not taken into consideration the records from greater depths than 10 metres. I myself am responsible for some of these records; the algæ often were detached, but sometimes it appeared as if they really had been growing at the depth recorded. I always, however, have entertained some doubt concerning this, and consequently prefer at present not to consider records from such depths. Regarding *Chlorochytrium inclusum* the record is correct, as it grew in *Turnerella*, which was attached to the bottom at a depth of 30 metres. For *Gomontia* and *Ostreobium* I have given the most common depth, down to about 40 metres, but I have also obtained these species, growing inside an old shell of *Mya*, from a depth of about 60 metres.

It should be further stated that I do not know the depth to be given for *Desmarestia ligulata*. This species has been found by Ove Paulsen between the Vestmannaeyjar and South-Iceland; I presume that it grew at a depth of about 20 metres.

Lower Limits of Growth in metres (see Table 7).

	About 5—10	About 15–20	About 25–30	About 35—45	About 60 and more
Red algæ	13	10	10	15	7
Brown algæ	19	8	4	5	3
Green algæ.....	16	..	1	2	..
Total...	48	18	15	22	10
			37		

In the above table 113 species are mentioned, of which 48 do not extend to a greater depth than about 10 metres, 18 extend to about 20 metres, 15 to about 30 metres, 22 to about 40 metres and 10 to about 60 metres and more. Thus there appears to be a floristic boundary at a depth of about 10 metres; while another boundary can be faintly distinguished at a depth of from about 30 to 40 metres, as there are 37 species which appear not to extend further downwards; and here, also, is situated the lower limit of growth of most of the *Laminariaceæ* which play the same rôle on the sublittoral bottom as the *Fucaceæ* play in the littoral zone. Exactly where the lower limit of growth, as regards the marine algæ in Iceland, is situated — whether it lies at a depth of about 60 to 80 metres or deeper — I cannot at present decide, but it is most probable that the vegetation at greater depths than 60 metres is, in any case, extremely poor in species.

According to the above statements the lower limits of the algæ are as follows: —

The littoral limit (Upper Littoral Zone)	53	species	26.77 %
The limit of low-tide	32	—	16.17 %
At about 10 metres.....	48	—	24.24 %
At about 20 metres	18	—	9.09 %
At about 30—about 40 metres	37	—	18.68 %
At about 60 metres and more	10	—	5.05 %
	198	species.	

By future investigations all these figures will undoubtedly be altered and many of them to no inconsiderable extent; but the four principal boundaries, namely the littoral limit, the 10-metre limit, the 30—40 metre limit and the absolute depth-limit will always remain evident.

As regards the absolute depth-limit I cannot make any definite statement. The dredgings which I myself have undertaken have all been conducted with a small dredge from a small rowing boat.

The positive results which are obtained with this small dredge are satisfactory enough when the material is inspected with sufficient criticism, but it should not be concluded with certainty from a negative result (that is, when absolutely nothing comes up from the bottom) that no plants grow there. In great depths, also, dredging is difficult from a small rowing-boat. In some places only, in SW. Iceland and E. Iceland, have I undertaken dredgings in a depth of about 80 metres, and the result has been negative. In those places where the plummet revealed a clayey bottom, it was certain that no plants were growing there. Off S. and SW. Iceland I have met with no vegetation at a greater depth than about 40 metres, but in Reyðarfjörður in E. Iceland, on the other hand, I have come across plants at as great a depth as about 60 metres. This might indicate that the vegetation extends further downwards in E. Iceland; but as the observations are too few, this point must remain undecided until further investigations are forthcoming.

It was a fairly common occurrence, especially in the fjords of E. Iceland, to encounter sunken fragments of algæ (often strictly littoral species) and of mosses in depths of more than 22 metres. In Seyðisfjörður I came across leaves of *Betula* and *Salix* at a depth of 14—20 metres.

C. H. Ostenfeld (the Ingolf Expedition) found *Lithothamnion laeve* in great quantities at a depth of 88 metres off the north coast of Iceland, and R. Hörring (on board the "Diana," off E. Iceland) found *Lithothamnion tophiforme* at a depth of 70 metres. In depths of from 60 to about 100 metres Hörring found, in addition, fragments of various algæ, amongst which were strictly littoral species, and of mosses which had evidently fallen to the bottom. In order to draw the attention of future investigators to this matter it must further be mentioned that Hörring brought home in spirits a young plant of *Laminaria saccharina* from a depth of from 81 to 104 metres (Mjóifjörður, 14.5.1898, St. XIII) and on the label was written "In the trawl were many large *Laminariæ* which had been torn away from the bottom." The *Laminaria* brought home appeared normal, and, if it had fallen to the bottom could only have lain there for a short time. What is most likely is that the trawl passed over an uneven bottom, and that the *Laminariæ* grew at a lesser depth than that mentioned; or is it possible that the deep-water form of *Laminaria saccharina* ranges so far downwards? I leave it to future investigation to decide this question.

VI. MARINE ALGAL VEGETATION AND SEA-GRASS VEGETATION.

The vegetation of the sea is naturally divided into two principal groups: the Plankton composed of the small plants floating passively in the water, and the Benthos which comprises the species attached to a substratum. In this article only the latter is dealt with.

The Benthos[1] falls naturally into two divisions, viz. the lithophilous vegetation, the communities of marine algæ (subformation of marine algæ, Halo-nereid communities, Warming, 72, p. 170), and the vegetation of loose soil (Enhalid-formation, Warming, 72, p. 177).

The Benthos has been divided in different ways. J. G. Agardh in 1836 (Novitiæ Floræ Sveciæ) divided the marine vegetation into three zones, a green zone above, a brown zone in the middle and a red zone lowest of all. Lyngbye in the same year, also divided the vegetation into three zones (Rariora Codana, printed 1879—80), a zone of green algæ *(Ulvaceæ)* being above, a zone of red algæ in the middle and a zone of *Laminariæ* below this. Ørsted (77), like Agardh, also divided the vegetation in the Øresund into three zones, but Ørsted has the merit of being the first to explain that the division of the zones depends upon the depth to which the light penetrates, and upon the colour of the light at the various depths.

Kjellman has divided the algal Benthos into regions. Where there is a tide, the littoral region is reckoned as being between the highest high-water mark and the lowest ebb-tide mark; where, on the other hand, there is no tide Kjellman reckons the littoral region as extending from the uppermost limit of the algal vegetation to a depth of $1^1/_2$—2 fathoms (34, p. 7). The sublittoral region extends from the lower limit of low-tide, or else from a depth of $1^1/_2$

[1] No notice is taken of the bacterial flora of the sea.

—2 fathoms, down to a depth of 20 fathoms; and finally the elittoral region stretches from the 20-fathom contour downwards. This division, unchanged in its main features, is generally employed. The boundary between the littoral and sublittoral regions is, I think, commonly supposed to be rather sharply defined in places with tides, and less sharply defined where tides do not occur.

By this division into three regions the algal Benthos is divided into three belts of different depth. Although the boundary lines thus drawn may be described as floristic boundaries, as regards many species, yet they cannot always be regarded as natural limits of vegetation. If natural limits of vegetation are to be drawn, several factors must be taken into consideration. From depth-records, pure and simple, a somewhat clear idea may naturally be formed of the conditions of light, but not of the salinity and warmth. If the conditions of light, salinity and warmth in those layers of water where the algal vegetation lives were known all the year round it would be easy to characterize the limits of the vegetation. The great importance of the salinity to algal vegetation is well-known and is emphasized by Rosenvinge (63), Svedelius (71), Börgesen (12) and Kylin (45), amongst others.

The ecological factors in the coastal waters round Iceland are not so well known that I am able to draw the natural limits of the vegetation by means of them. My starting point is, therefore, the vegetation itself, and from the appearance of the vegetation it is possible, to a certain extent, to form an opinion as regards the ecological factors, in the same way as an opinion may be formed from these concerning the appearance and composition of the vegetation.

The marine algal vegetation divides itself into several zones as the Benthos does in fresh water. The divisions between the zones in the sea are very distinct: some species seem to be spot-bound or very sensitive to changes of level; other species may occur in two or several zones; but it depends especially, I think, on the quality of the water, the intensity of the light and, where there are tides, on the period of exposure (in the littoral zone).

By studying the vertical distribution of the species and associations, I have come to the conclusion that the marine algal vegetation may be divided into three zones almost parallel one with another: the Littoral Zone, the Semi-littoral Zone and the Sublittoral Zone.

The Littoral Zone understood in a more restricted sense is identical with the upper littoral zone and extends almost to the

low-water mark of neap-tide, and is exposed during each low-tide; the upper littoral zone is, then, the littoral zone proper, which doubtless corresponds exactly with Kolderup Rosenvinge's limitation of the littoral zone in Greenland, but not entirely with Börgesen's limitation of the littoral zone in the Færöes, as some of the Færöese littoral associations seem to belong to the next belt.

The semi-littoral zone extends from about the low-water mark of neap-tide to a depth of about 10 metres, and thus extends over the lower littoral zone, and even lower than that. In reality this zone comprises the lower littoral zone including stragglers below the low-water mark of spring-tide to a depth of 10 metres. That part of the zone lying in the lower littoral zone is laid bare at and about spring-tide, but is submerged at neap-tide.

The sublittoral zone extends from the low-water mark of spring-tide to the absolute depth-limit.

There seems to me to be no reason for calling any part of the Benthos elittoral. Even if the 40-metre contour is a lower limit of growth in the case of several species, and is, approximately, the lower boundary of the *Laminaria*-community, yet the upper boundary of the red-algæ communities which extend further downwards than 40 metres lies much higher, and the 40-metre contour thus cuts straight through natural communities. It cannot, therefore, be considered the principal boundary as regards the whole of the constantly-submerged vegetation. Strömfelt (l. c.) is of the opinion that, possibly, elittoral vegetation does not exist on the coasts of Iceland. According to Kjellman the elittoral vegetation is extremely poor in species, and probably has a limited distribution everywhere in the northern seas. From what has been said above respecting the 40-metre line, and from a comparison with Greenland (Rosenvinge, 63) and the Færöes (Börgesen, 11 and 12), it is obvious that a division of the constantly-submerged vegetation at this depth-line is not quite natural in the northern seas. It is more correct, therefore, to do as Rosenvinge and Börgesen do, and to class the vegetation as sublittoral down to the absolute depth-limit.

In the following I do not employ the term "region," which is now generally used to describe somewhat limited subdivisions of

the vegetation, as I have thought it better to designate the algal Benthos taken as a whole by this word, and to call it the "algal region."

I have also avoided the term "formation." The algal formations established by Kjellman and others are not real formations, but only associations (Warming, 72, p. 171), and the entire marine algal vegetation is given as a subformation of marine algæ (Halonereid; Warming, 72, p. 169). I do not think that the term "formation" should be used in connection with the algal region in any other sense than that in which it is used in connection with land vegetation. As the term "facies" cannot be used in English to denote a vegetation-unit (Warming, 72, p. 146, foot-note) I have avoided it.

I divide the vegetation in each of the three zones into associations, and where I think they are closely allied I combine them into communities.

Sometimes by the suffix "etum" is meant the subordinate part of an association, and sometimes a vegetation-unit which almost corresponds with an association.

ACCOUNT OF THE MARINE ALGAL VEGETATION AND THE SEA-GRASS VEGETATION.

A. The Marine Algal Vegetation.
  a. The Littoral Zone.
    aa. The Photophilous or strictly Littoral Communities.
      1. The Prasiola stipitata-association.
      2. The Community of Filiform Algæ.
      3. The Community of Fucaceæ.
        + The Pelvetia-Fucus-spiralis-belt.
        ++ The Fucus-belt.
      4. The Enteromorpha-association.
      5. The Acrosiphonia-association.
    bb. The Shade-vegetation.
      6. The Hildenbrandia-association.
      7. The Rhodochorton-association.
    cc. The Vegetation of Tide-pools.
  b. The Semi-littoral Zone.
      8. The Monostroma-association.
      9. The Chorda-association.

10. The Community of Rhodymenia.
11. The Polysiphonia urceolata-association.
12. The Community of Corallina.
13. The Crustaceous Alga-association.

c. The Sublittoral Zone.

14. The Community of Laminariaceæ.
15. The Desmarestia-association.
16. The Deep-water Community of Florideæ.
17. The Lithothamnion-association.
18. The Community of Crustaceous Algæ.

B. The Sea-grass Vegetation.

1. The Zostera-association.

A. The Marine Algal Vegetation.

a. The Littoral Zone.

The Littoral Communities. The littoral vegetation is composed of several communities. These are left dry during low-tide, with the exception of the pool-vegetation; but the period during which the different communities are left dry varies greatly. I am not prepared to state accurately the period of exposure, but I presume that the lowest littoral communities will be laid bare for about 1—2 hours under normal conditions, while the uppermost communities will be submerged for about one hour, and will be laid bare for about 11 hours. On exposed coasts the period of exposure is shortened by the beat of the waves. The ecological factors differ not a little in the uppermost and lowermost part of the littoral zone, and because of this difference the vegetation is divided into longitudinal belts along the coasts. The littoral vegetation falls naturally into three divisions: the light-loving or strictly littoral communities, the shade-loving communities, and the pool-vegetation. In the following description of the vegetation, the communities in each of the three zones are arranged as far as possible according to depth, and in such a way, that the uppermost come first and the lowest come last. This rule, however, cannot always be adhered to.

aa. The Photophilous or strictly Littoral Communities.

These communities are found in places in the littoral zone which are directly exposed to light during low-tide. They are composed of blue-green, green, brown and red algæ; the

brown algæ are found most abundantly, the green algæ come next, red algæ occur less frequently, and blue-green algæ are found in the smallest quantity. The substratum is either rock — solid rock or else talus of debris — or pebbles, or in many places consists of gravel, clay or mud. The perennial species prefer almost exclusively the rock-substratum; but they occur, though very seldom, on other substrata, and are then, as a rule, dispersed here and there on small stones, viz. on a gravel-clay soil at the head of the fjords. The annual, short-lived species also occur most frequently on a rock-substratum, but they also occur fairly frequently on the pebbles of the littoral zone.

1. The Prasiola stipitata-association.

This association extends furthest upwards and is found well developed on the rocks in several places round the coasts. It is usually almost on a level with the *Verrucaria-maura* belt and, upwards, sometimes approaches the outposts of the land-vegetation. At the highest water-level it is covered by the sea for a short period, or is, at least, washed by the breaking waves; but such high water occurs only rarely, and in normal conditions this association must, without doubt, be content with the spray from the waves during spring and summer. On less exposed coasts this association is, as a rule, sharply defined from the community of filiform algæ which exists below, but on a very exposed coast the boundary is more variable.

The dominant species in this association is the small, leaf-like *Prasiola stipitata*, which grows very socially upon the tops of flat rocks. As it has its distribution almost exclusively in this belt it seems natural to designate the association by its name. It is essentially adapted to live in the air, and is capable of withstanding desiccation well, which may be perceived, *inter alia*, by the fact that it does not seek clefts and crevices but grows on surfaces which are exposed to light, wind and weather. The density of the vegetation must also afford each individual some protection against desiccation. In spring and summer long periods must occur during which this association is not wetted by the sea, and, during summer drought, I have often seen *Prasiola stipitata* as dry as a bone upon the rocks. *Prasiola furfuracea* also occurs side by side with this species, but is rarer.

Species and varieties of species, such as *Enteromorpha intesti-*

nalis f. *micrococca* and *Rhizoclonium riparium,* which essentially belong to the lower belts, but can accommodate themselves to life in the air, are also included as members of this association. They are species which, owing to their structure or their manner of growth, are capable of enduring desiccation. *Enteromorpha intestinalis f. micrococca* has, as is well known, small cells, the walls of which are very thick, the inner walls, in particular, being highly thickened, serving possibly as reservoirs for water. It prefers fissures in the rocks, where, as a rule, it is less exposed than the species characteristic of the association. Sometimes, however, I have come across *f. micrococca* growing, like *Prasiola stipitata,* on flat rocks manured by birds, but then it had a different aspect and, at first sight, somewhat resembled *Prasiola. Rhizoclonium* also occurs in fissures, where, owing to its manner of growth — that is to say its pulvinate form — it is protected from desiccation during the long periods of drought. *Calothrix scopulorum* also occurs as a member of the *Prasiola*-association and forms *Calothriceta* of limited dimensions; the individuals are procumbent and are placed so closely together that the rock is completely covered, and thus they protect each other from desiccation. From a biological point of view, the manner of growth of this species, in the dry condition, is similar to that of the crustaceous algæ. *Enteromorpha intestinalis f. minima* also occurs in this community.

The species in this community grow, as a rule, in small, pure societies which form a narrow, though not a continuous belt along the coast. This belt is situated higher on exposed coasts than it is on those which are less exposed.

The *Prasiola*-association is undoubtedly commonly distributed in neighbouring countries, but the constituting species may be different. In Greenland (Rosenvinge, 63, p. 200) *Calothrix scopulorum, Ectocarpus maritimus,* and *Rhizoclonium riparium* occur only in the uppermost part of the littoral zone. This vegetation, however, scarcely corresponds with the *Prasiola*-association, but rather with that occurring below. In the Færöes, however, an exactly corresponding association is found, which Börgesen calls the *Chlorophyceæ*-formation (12, p. 712). The Færöese *Chlorophyceæ*-formation, however, appears to be more luxuriant and is composed, in part, of other species. A *Prasiola*-association (Foslie, 18, p. 127) similar to that of Iceland is evidently found in Finmark.

2. The Community of Filiform Algæ.

It is not easy to find a suitable name for this community. It is composed of several species which are all equally common and are all dominant to almost the same degree. As almost all the species are filiform and non-branching, it seems to me that the community may fitly be named in accordance with the form of the frond.

The community of filiform algæ forms a narrow belt, which is often continuous along fairly considerable stretches of the coast, at about the average limit of high water. The vertical height of the belt is inconsiderable, about one foot, but the breadth conforms somewhat to the slope of the coast, and may attain to 3—4 feet, or even more. This vegetation is very well developed on the face of vertical rocks, and the various associations of the community can be distinctly seen, one above the other, as parallel bands of varying colour. The species which occur most frequently are the following: —

Ulothrix flacca.
Urospora mirabilis.
Monostroma groenlandicum.
Bangia fuscopurpurea.
Porphyra umbilicalis f. typica.

These are all dominant species, and form extensive associations, of which some are pure and others mixed. Other species may also occur, but only in lesser quantities.

The Ulothrix-association, as a rule, reaches highest up the cliff. The principal species is *Ulothrix flacca*, which forms a distinct belt, extending rather far in a horizontal direction. On rock-walls, the filaments are often comparatively long, and are moved to and fro over the entire belt by the beat of the waves or the ripple of the sea at flood-tide; during the period of exposure they hang down, pressed closely against the face of the rocks. The outer filaments protect the underlying ones from desiccation during low-tide, and thus it happens rather frequently that the outer layer is dry while the protected layer — that nearest to the rocks — is moist. In this way the social growth of the plants protects them against desiccation (cf. Rosenvinge, 63, p. 201), at any rate under normal conditions, and so long as no exceptionally long periods of drought occur. It happens rather frequently, however, that the *Ulothrix*-vegetation becomes quite dry during low-tide. This is especially the case when the vegetation occurs on boulders in the littoral zone where, when the water subsides, the filaments radiate

from the highest point of the stone. Such a stone-surface is smooth and dries more quickly and completely than the uneven face of the rock. This vegetation appears to maintain itself well in spite of being completely dried up, day after day, during low-tide, — during the nocturnal low-tides, naturally, it is dried up to a much lesser extent. As a rule, such a dried-up *Ulothrix*-vegetation is so tightly adpressed to the surface of the stone that it can only be removed by being scraped away with a knife. Thus, owing to desiccation, it appears, from a biological point of view, to have assumed a crustaceous form, which evidently diminishes the evaporation from its surface.

The other species which occur in great quantities in this association, such as *Urospora mirabilis* and *Monostroma groenlandicum,* act biologically in a similar manner to *Ulothrix flacca.* Both these species are found fairly frequently growing among *Ulothrix flacca*; and as I think that these species may in several respects be comprehended in one biological unity, I consider them members of the same association, although they both occur in pure growths *(Urosporetum, Monostrometum).*

While *Ulothrix flacca* and *Urospora mirabilis* are commonly distributed, the distribution of *Monostroma groenlandicum* is more restricted, for this species can be reckoned as commonly distributed only in E. Iceland.

Of the species which are rare or of local occurrence, and which are reckoned in this association, the following may be mentioned: *Ulothrix pseudoflacca, Ulothrix consociata* var. *islandica* and *Urospora Hartzii.* In addition, *Enteromorpha intestinalis* f. *micrococca* and *Rhizoclonium* occur here as they do in the *Prasiola*-community.

Of these species *Ulothrix consociata* var. *islandica* requires to be described most fully. It is very social, and grows in cushion-like masses higher up, as a rule, than the other species of the association. It appears to be protected from desiccation both by its manner of growth and by the thickness of its cell-walls.

Codiolum gregarium I have found to be of very social growth, covering comparatively large stones as pure *Codioleta.* It is most nearly related to this association.

The structure of the frond in this association displays various peculiarities, which must be considered as being beneficial to the plant during the period of desiccation; for instance, the interior of the frond of *Monostroma groenlandicum* is filled with a gelatinous

mass. Rosenvinge (63, p. 201) has pointed out that this mass must be of importance as a reservoir for water during low-tide. *Ulothrix flacca* also has very thick cell-walls, especially in the fruit-bearing filaments (cf. Rosenvinge l. c.). The remaining species also are rather thick-walled.

Although the *Ulothrix*-association is distributed to an extraordinary extent, yet it cannot be expected to be found everywhere. It prefers that part of the littoral zone which is rocky and stony, and grows luxuriantly on a somewhat exposed coast, and even, indeed, on one which is very exposed. It also extends right into the fjords, if the nature of the shore is favourable to it.

The succession of the associations of filiform algæ is seen most distinctly on vertical rocks on somewhat exposed coasts, where the *Ulothrix*-association appears uppermost; but where the substratum is uneven — a talus of debris or irregularly heaped-up fragments of rock — the zonal division of the community becomes less apparent, and it may then well happen that the *Bangia*-association extends above the *Ulothrix*-association.

The Bangia-association prefers the rocky part of the littoral zone, and vertical rock-walls in particular, and is only rarely found in the stony part of that zone; it occurs normally below the *Ulothrix*-association, but where the latter is absent the *Bangia*-association is not infrequently the algal vegetation which reachest highest. In many places it has an extremely wide horizontal distribution, and is often perceived at a considerable distance as a reddish-brown band in, and at the edge of, the water. This *Bangia*-belt may attain a considerable breadth, as much as three feet, and it often displays several shades of colour. Thus, in a less exposed spot facing the south, I have seen the uppermost part coloured green, the middle part brownish and the lowest part a fresh reddish-brown. This is certainly connected in some way with the long period of drought which, when the weather is calm or the wind blowing off the land, may well continue from neap-tide till about spring-tide. During the period of drought *Bangia* behaves somewhat similarly to *Ulothrix flacca*. The filaments are rather long, as long as 10 cm., and are very closely packed together; on vertical rocks they hang straight down during low-tide, and are, on the whole, protected by their structure and manner of growth from too severe desiccation, in the same way as has been mentioned in connection with the *Ulothrix*-association. The *Bangia*-belt is, as a

rule, distinctly separated from the *Porphyra*-association which exists below, but sometimes the two belts are concurrent, even over rather large areas.

The Porphyra-association is formed by *Porphyra umbilicalis* f. *typica*. It might be justifiable to incorporate this association in the *Bangia*-association, but I prefer to reckon it as a distinct association; partly on account of the difference in the form of its thallus, and partly because *Bangia* is confined to its narrow belt, while *Porphyra* occurs also in other associations in and below the *Fucus*-belt.

The *Porphyra*-association occurs on a rocky substratum. On vertical rock-faces it is very luxuriant, and then forms a continuous belt below the *Bangia*-association. Where the littoral zone has large fragments of rock, that is to say consists of a talus of debris, this species grows higher than any others upon the fragments at the water's edge. In such places no continuous belt is formed, but the species occurs in small scattered patches on the upper part of the blocks of stone. This patchy distribution of the vegetation may extend horizontally over either a small or a wide area, according to the form of the coast. The vertical height of the belt is always inconsiderable.

During the period of drought *Porphyra* hangs down on the vertical rock-faces, the thallus being repeatedly folded, according to its length; the individuals in the upper rows of the association often, to some extent, covering those below and thus, in some ways, recalling the behaviour of the above-mentioned filiform algæ; on the blocks of stone, also, the thallus is folded up in accordance with its length, and rests on the surface of the stone. The folding apparently serves to reduce evaporation during low-tide, as the evaporating surface is thereby diminished; the folding may well be of importance also in counteracting the effect of the light. As the folds of the thallus are produced while the water is subsiding, it is probable that some of this is retained between them, especially on a flat substratum; on a sloping or vertical substratum, however, the quantity of included water would be very small. This circumstance is probably of some importance, and has also been emphasized by Börgesen (12).

The *Porphyra*-association seems to maintain its freshness for a considerable time, and I saw it with its usual dark purple colour in several places in E. Iceland in the summer; but round about

Reykjavík, especially later in the summer, it frequently has a yellowish-brown tinge.

These associations, owing to local conditions, naturally are not found everywhere along the coasts. At times they are all present, and then generally in the succession here recorded; at other times only one or another is present. Thus, in some places, the upper limit of the marine algal vegetation is indicated by the *Ulothrix*-association, and in others by the *Bangia* or the *Porphyra* association; in places the entire community is absent, and then the boundary is marked by *Pelvetia, Fucus spiralis* or other *Fucaceæ.*

A comparison with the adjacent coasts shows that this community is found both in Greenland and in the Færöes though it does not behave in quite the same manner in both places. In Greenland a *Monostroma groenlandicum*-association is found which is composed of *Monostroma groenlandicum, Ulothrix flacca* and *Urospora mirabilis,* all intermixed with *Bangia fuscopurpurea.* This association occurs in the middle part of the littoral zone. A *Porphyra umbilicalis*-association occurs also in the upper part of the littoral zone. Thus, the same species occur in Greenland as in Iceland, although possibly they are not present in the same numerical proportion. But one great difference exists, namely that the Greenland community is found in the middle of the littoral zone, while the Iceland community is found much higher up. There is a similar difference in the occurrence of the *Porphyra;* as it is found in fissures of the rocks in the upper littoral zone in Greenland, while in Iceland it grows upon the surface of the rocks. This difference is probably due to a difference in the climate.

It is possible that the same community (Börgesen, 12, pp. 716, 719) may be found at an even greater height in the Færöes than in Iceland. In the Færöes the species are only partially similar, because *Monostroma groenlandicum* is wholly absent, and *Ulothrix flacca* does not seem to play such an important part there as it does in Iceland. The community of filiform algæ is, in all probability, common along the coast of Norway (Foslie, 18; Börgesen, 12, pp. 719—720; Boye, 10, p. 20).

3. The Community of Fucaceæ.

This community is the dominant one in the littoral zone and comprises six associations, of which the first two, the *Pelvetia*-association and the *Fucus spiralis*-association, are more closely

connected with each other than they are with the remaining associations, which also are mutually very closely connected. In this way the community may be divided into two belts, of which the first comprises the two first-mentioned associations, and the second the remaining four. The *Pelvetia-Fucus-spiralis*-belt is narrow. It is situated in the upper part of the littoral zone, at, and just below, lowest high-water mark, i. e. flood-mark at neap-tide. It has only one layer of vegetation, as there is no undergrowth worth mentioning, and it is entirely devoid of epiphytes; it is submerged in normal conditions for a very short time.

The second, the *Fucus*-belt is broad; it occurs in the lower part of the upper littoral zone, just above low-water mark of neap-tide. The vegetation occurs in two, and sometimes in three, layers and epiphytes are present in abundance. The vegetation is submerged much longer than in the first belt. Thus, these two belts differ so greatly that they cannot be treated together.

The Pelvetia-Fucus-spiralis-belt.

This belt is of common occurrence, and its vegetation is luxuriant in S. and SW. Iceland, but in the other parts of the country is sparse and devoid of *Pelvetia*. This belt is not continuous except along short distances, and its vertical height is inconsiderable; but the breadth may sometimes be fairly considerable, especially on very gently sloping coasts. It grows on rocky coasts, and in places where these consist of a talus of debris the vegetation is distributed in patches which is a natural consequence of the surface, the limit of the association being rather sharply defined downwards. *Pelvetia* and *Fucus spiralis* do not grow intermixed, but occur in two pure and distinct associations. They grow luxuriantly on exposed coasts; in the most exposed parts of the coast, however, they seem to recede. Thus, this belt was either absent from, or was poorly represented on the most exposed points at the extremity of Snæfellsnes and of the Vestmannaeyjar and at the extreme end of Reyðarfjörður; but there occurred in its place surf-forms of *Fucus inflatus* (f. *exposita* and f. *dendroides*).

The Pelvetia-association (Fig. 3) always occurs highest of all. As already mentioned it is found in S. and SW. Iceland only, but there it occurs in great abundance in many places; in some places its vegetation is poor, and sometimes only a few scattered individuals are found. This is more particularly the case in places where *Pelvetia*

appears to have extended too high upwards, and where, when the weather is calm, it is not wetted daily by the sea at and about neap-tide. On a warm summer's day *Pelvetia* can become so dry in such places that, when gathered, it needs no further drying — the same may also be the case with *Fucus spiralis*. The individuals of *Pelvetia* which grow at that height, i. e. sometimes right up in the *Verrucaria maura*-belt, are usually very small (about 2 cm. in height) and occur closely pressed to the rock; then they are often

Fig. 3. *Pelvetia canaliculata* above, *Fucus spiralis* below. Illustration of a typical *Pelvetia-Fucus-spiralis*-community. Reykjavík, Aug. 13, 1909. (From phot. by Hesselbo.)

found especially in crevices, and the new fronds may bear a surprisingly close resemblance to a rosette. Lower down, where the vegetation is luxuriant, the plants are about 8 cm. in height. *Pelvetia* is the smallest of the *Fucaceæ* on these coasts; it differs from the others not only by its small size, but also by its lighter, yellowish-brown colour, and its channelled frond, etc. The channelled frond must be useful to a plant which is so exposed to the desiccating action of the air as is the case with *Pelvetia*, because, by reason of their being rolled, the under-side of the fronds is less exposed to wind and weather.

It is characteristic of the zonal division of the *Fucaceæ* on the

coast that the smallest species *(Pelvetia, Fucus spiralis)* are arranged in a separate uppermost belt, while the larger species are arranged in belts lower down, and the largest species (f. *inflatus*, if the large broad-fronded forms are included) occurs lowest of all.

The Fucus spiralis-association (Fig. 4) is more luxuriantly developed than the *Pelvetia*-association and occurs just below it. On flat or very gently sloping rocks this association forms a comparatively broad belt, but on a steep coast only a narrow one. Its relation

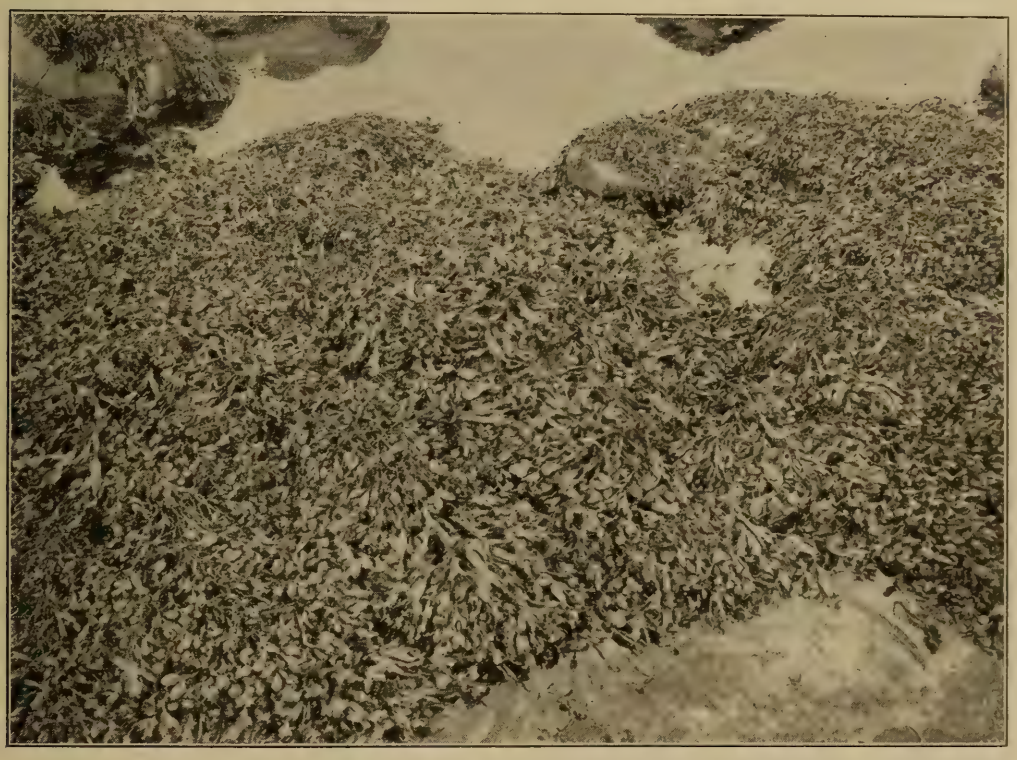

Fig. 4. *Fucus spiralis.* Part of a luxuriant *Fucus spiralis*-vegetation below the *Pelvetia*-association. Reykjavík, Aug. 13, 1909. (From phot. by Hesselbo.)

to exposed coasts has already been discussed. It may happen with *Fucus spiralis,* as with *Pelvetia,* that it extends to so great a height that at times it is not wetted daily by the sea. In such a case the individuals are as a rule smaller, and are often rather strongly spirally twisted; they may be found lying quite dried up on the rocks, apparently without being damaged thereby. The twisting of the fronds may possibly result from the drying process.

This belt is, as a rule, somewhat sharply defined from the *Fucus vesiculosus*-belt situated below. Although it does not always happen that there is any distance worth mentioning between *F. spiralis* and the upper outposts of the *Fucus vesiculosus*-association, yet the boundary is almost always sufficiently distinct.

This belt behaves similarly in the Færöes (Börgesen, 12, p. 744). Both Boye (10) and Hansteen (25) mention a *Pelvetia*-formation from western Norway without mentioning *Fucus spiralis*. In Finmark *Fucus spiralis* has the same manner of growth as in Iceland (Foslie, 18, p. 66).

The Fucus-belt.

The four associations which belong to this belt are the most extensive in the littoral zone and three of them are found everywhere on rocky coasts. The breadth of the belt naturally is dependent on the degree of the declivity of the coast in addition to the nature of the substratum. This belt occurs everywhere along the coast, but it is not luxuriant to the same degree everywhere. Its vegetation is so dense that the bottom is entirely covered, or almost so, by the *Fucus* plants which during low-tide partly lie prostrate upon the rocks and partly hang on them; seen from a distance it appears as a brown-coloured belt of varying width along the coast. These associations are usually found on a rocky substratum, but they may also occur on a fairly firm gravelly bottom; the latter is especially the case at the head of the fjords. In such places their vegetation is poor and the species grow scattered, attached especially to small stones which are somewhat firmly embedded in the gravelly bottom. *Fucus* plants are also found scattered on wood-work, for instance, on wooden piles. On the whole the species of *Fucus* require a stable substratum. The dominant species are the following: —

Fucus vesiculosus.	Fucus inflatus.
Ascophyllum nodosum.	Fucus serratus.

The first three species are common and grow very luxuriantly along the coast; *Fucus serratus*, on the other hand, was found only in a few places in S. and SW. Iceland; in Hafnarfjörður it grew very socially, while in the Vestmannaeyjar it had a more scattered growth.

The individuals of these species form pure associations which usually occur in regular succession: *Fucus vesiculosus* growing uppermost, *Ascophyllum* in the middle and *Fucus inflatus* (and *Fucus serratus*) lowest of all. This succession is distinctly observable in places where the bottom is flat and gently sloping. But where the bottom is uneven — a talus of debris — the divisions between the belts are less regular, but can, as a rule, be discerned. It does not, however, follow that the associations always occur quite regularly;

the species being rather frequently found intermingled; the *Ascophyllum*-association, in particular, does not appear to be as spot-

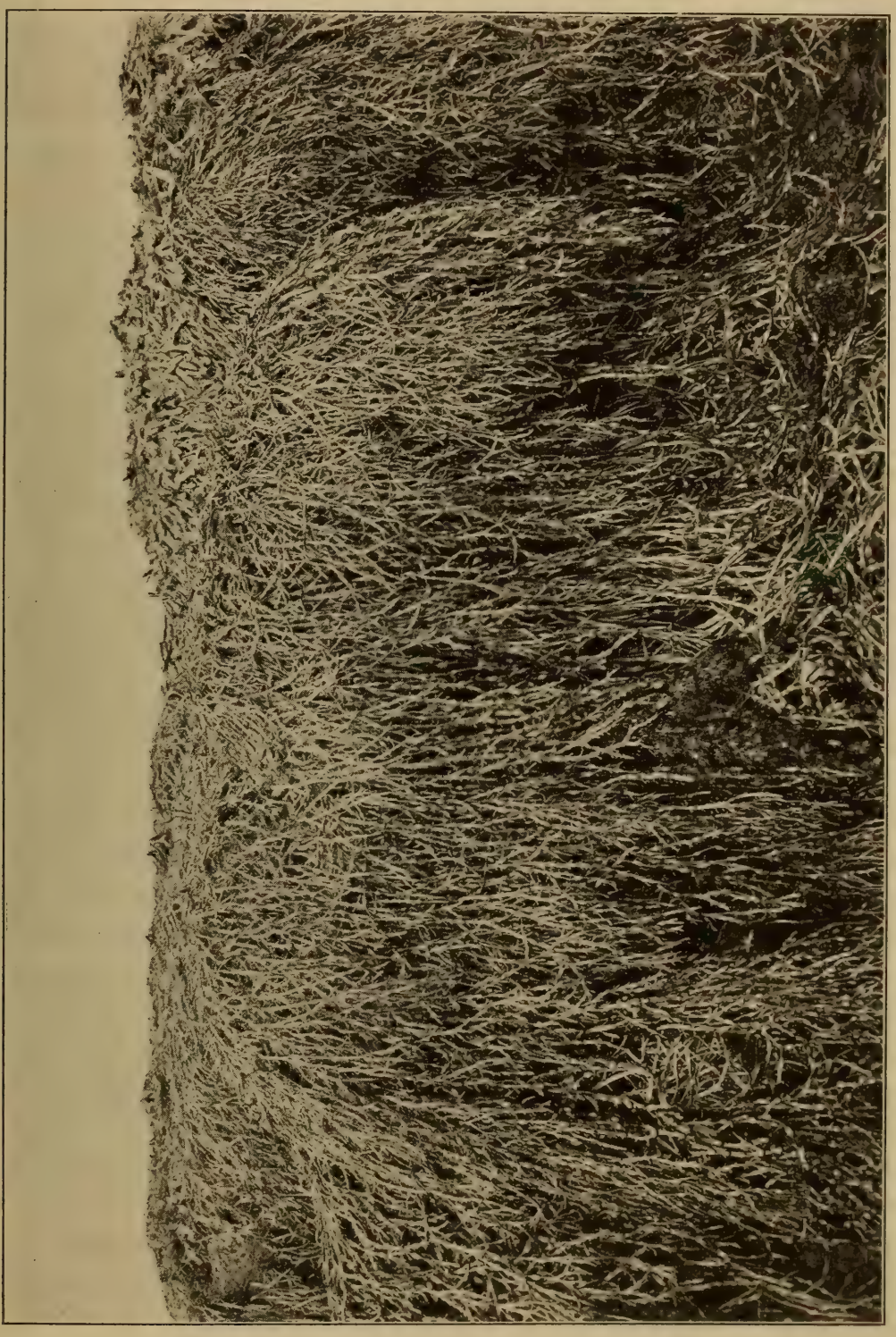

Fig. 5. *Ascophyllum nodosum*. with *Polysiphonia fastigiata* as epiphyte, hanging down on the rocks. Reykjavík, Aug. 13. 1909. (From phot. by Hesselbo.)

bound as the others. It generally occurs somewhat below the middle of the area occupied by the community, but may occur also higher up, even at the very top. It is, however, a fairly constant fact that

Fucus vesiculosus grows highest and *F. inflatus* lowest. How the species behave when left dry is mentioned in connection with each association.

The Fucus vesiculosus-association, as already mentioned, is uppermost and often borders closely on that of *Fucus spiralis*. It varies extremely in extent, according to the character of the coast. The breadth may vary from about one foot on vertical rocks to several fathoms on a gently sloping coast.

Fucus vesiculosus extends right into the innermost part of the fjords, which is generally considered a protected coast; if there is a favourable substratum there, its growth may be fairly luxuriant. It also grows very luxuriantly on slightly exposed coasts, i. e. where a landward wind is sometimes both frequent and tempestuous, but where breakers are extremely rare. If the exposure is increased, it seems that *F. vesiculosus* not only decreases in number of individuals but also seeks for shelter between the rocks. Then, gradually, it retreats lower into the littoral zone, and *Ascophyllum*, which is evidently better able to withstand the heavy seas, advances. This is seen very distinctly at Reykjavík, where the coast must be considered somewhat exposed, because the south-west, west, and north winds are frequently stormy and occasion heavy seas. If we take a bay which is bounded by a rocky promontory, we see at the head of it a luxuriant *Fucus vesiculosus*-association; this extends out upon the promontory, growing gradually narrower as it extends outwards; in the vicinity of the point itself, the alga has commenced to seek for shelter, and at the extreme end of the point it has disappeared and *Ascophyllum* has occupied its place, and then *Fucus vesiculosus* is either found not at all or only a few individuals of it occur high up in the *Ascophyllum*-belt. What is here seen on a small scale is repeated on a larger scale on proceeding from the head of the fjord outwards to the extreme point of the peninsulas. Thus, *Fucus vesiculosus* was not observed on exposed points at Øndverðarnes (the extreme point of Snæfellsnes), while *Ascophyllum* and, naturally, *Fucus inflatus* also, were found in abundance. On the most exposed points of the Vestmannaeyjar *Fucus vesiculosus* was also absent, while both of the others occurred plentifully.[1] Thus, *Fucus vesiculosus* behaves in Iceland precisely as it does in the Færöes (Börgesen, 12, 11).

[1] Strömfelt (70) records *Ascophyllum* as growing above *Fucus vesiculosus* at Hólmanes in E. Iceland.

Generally this species forms a pure association, but yet, sometimes, it and *Ascophyllum* can grow intermixed.[1] It is always submerged at high-water, but seems well able to withstand desiccation at low-water, when however the upper side of the frond dries up considerably, especially on rocks which face the sun, and may then — and this is true of *Fucus inflatus* also — be bent upwards, or even slightly distorted, at the apex, though never to the same extent as is the case with *Fucus spiralis*. When such a branch is lifted up, it can be seen that the under side is moist, even on a warm summer's day. During low-tide the *Fucus* plants lie prostrate on the rock, one plant overlying the other, or one branch of the frond covering the other, and in this way some water is retained amongst the plants.

Naturally, this applies also to the members of the other associations in the *Fucus*-belt. Those individuals which hang freely from the rocks are exposed more than others to desiccation.

The Ascophyllum-association differs from the other associations in its light-brown colour, and, in addition, by the occurrence of *Polysiphonia fastigiata*, which grows very luxuriantly on it in S. and SW. Iceland; it is often somewhat singular to see the light-yellow *Ascophyllum*-belt with the numerous dark reddish-brown patches of *Polysiphonia*.

So far as the behaviour of the species during exposure to the beat of the waves is concerned I must refer to the above-mentioned remarks, and can only add that at times it may also occur in the most exposed places, but no longer in the uppermost belt. Here it gives place to the surf-forms of *Fucus inflatus* (f. *exposita*, f. *dendroides*), which form a narrow belt at the upper boundary of the *Fucus*-belt. *Ascophyllum* occurs, then, between this and the real *Fucus inflatus*-belt, which retains its usual position. In a few places, however, on the most exposed points, *Fucus inflatus* only is found.

The Fucus inflatus-association. When exposed, this species behaves conversely to *Fucus vesiculosus* and grows most luxuriantly on exposed coasts. Thus, it behaves in Iceland as it does in Greenland (Rosenvinge, 63) and in the Færöes (Börgesen, 12). In Iceland, as in other places, the species varies extremely and must be considered very capable of adapting itself to varying circumstances, especially as regards exposure. The association can — in accordance with the exposure — be divided into three belts: — The Surf-belt, the Wave-belt, and the Calm-belt.

[1] The epiphyte-vegetation is mentioned subsequently.

The Surf-belt, as previously stated, occurs at the upper boundary of the *Fucus*-association on rocky coasts which are very much exposed. I have seen such a belt at Øndverðarnes in SW. Iceland, in the Vestmannaeyjar in S. Iceland and at Vattarnes in E. Iceland. Strömfelt (70) has noticed a similar belt on Seley in E. Iceland. It will probably be found, on further investigation, that the surf-belt is far more widely distributed along the coasts than is recorded above. As a rule, the individuals in this belt are of low growth; the frond is leathery, and very thick in proportion below, and rounded, but tapering evenly upwards and becoming thinner; above, it is often excessively branched. The height of the individuals varies to some extent, f. *dendroides* is the highest, while f. *exposita* attains only an insignificant height (5—9 cm.). A similar surf-belt occurs in the Færöes (Börgesen, 12), although the vegetation is possibly more luxuriant there than in Iceland.

The Wave-belt (Fig. 6) comprises the ordinary *Fucus inflatus*-belt. As a rule, it is exposed to the movement of the waves, a movement which is often very violent indeed; more rarely it is exposed directly to the breakers. Here the species occurs in its typical form which shows a considerable variation in the breadth and consistency of the thallus. In very exposed places the branches of the frond are comparatively long and narrow and leathery, but where the movement of the waves is less felt, the frond is usually broader. The vegetation of this belt is generally very luxuriant, and covers the substratum entirely. Often, however, the vegetation occurs in patches, owing to the surface-features of the shore. Such a mode of occurrence is met with, for instance, where the shore is a wild talus of debris consisting of large scattered blocks of stone, or where the solid rock has a similarly uneven surface owing to erosion by the sea. There a belt is formed around each block of stone, while the hollows between them are occupied by semi-littoral or sublittoral vegetation, or by stragglers from these zones.

The Calm Belt is lowest of all, often at the boundary between the constantly submerged and the lower littoral vegetation, and sometimes forms small offshoots of vegetation[1] below that boundary. Here the movement of the waves is least felt, and the frond of the

[1] The species varies from the principal form to two kinds of dwarf-forms — a small "surf-form" of tough texture, and a small "pool-form" of delicate texture. The pool-form-association *(F. inflatus* f. *linearis)* may be regarded as the fourth belt, which should then be termed the Delicate Belt (see under The Vegetation of Tide-Pools, p. 125).

plants is also usually broader. In this belt the broad forms are to be found; they may occur both with and without air-bladders. This belt is as a rule poorly developed, and is often non-continuous. Within Hvammsfjörður, in bays protected from the surf, but where current-movements are felt to a certain extent, I have observed, below low-water mark, semi-littoral stragglers from the *Fucus*-community (i. e. from the *Fucus inflatus*-association). In a similar locality I saw *Ascophyllum* occurring semi-littorally.

Fig. 6. *Fucus inflatus* (sterile plants) lying prostrate upon the rocks. Above, hanging *Ascophyllum*. Reykjavík, Aug. 13, 1909. (From phot. by Hesselbo.)

The Fucus serratus-association was especially luxuriant in Hafnarfjörður on both sides of the fjord, some distance from the head of it, and occurred lowest of all in the *Fucaceæ*-community. In the Vestmannaeyjar the species grew scattered here and there, but was not found in the most exposed places. Sometimes on exposed coasts it was found growing in pools in the middle of the littoral zone.

The Epiphytes and Intermixed Species of the Fucus-belt. As is well known, an abundance of epiphytic vegetation exists in the *Fucus*-belt, at any rate at times. Many of the species grow socially and often occur in such quantities, that they set their stamp upon the vegetation. These species may be divided into those

which grow exclusively, or by preference, on the *Fucaceæ*, and those which occur as frequently on other substrata and must consequently be considered chance visitors.

Only one single species, *Polysiphonia fastigiata,* is exclusively confined to the *Fucus*-belt (Fig. 7). It is well known that this species grows only on *Ascophyllum nodosum,* into the frond of which it puts its rhizoids,[1] although its distribution does not coincide entirely with that of the latter. While *Ascophyllum* is common everywhere along the coast of Iceland, *Polysiphonia fastigiata* is common only in S. and SW. Iceland; it has been found, also, in a single place in NW. Iceland. Thus it keeps to the warmer parts of the sea off the coasts of Iceland, but even within this area it may be absent from coasts where the sea-water mixes abundantly with the fresh water. It did not occur for instance at Borgarnes, nor on the nearest islands, although *Ascophyllum* occurred in great quantities together with *Fucus vesiculosus* and *Fucus inflatus.* There the sea-water is freely mixed with water from the large glacier-torrent of Hvítá in Borgarfjörður. *Polysiphonia fastigiata* does not seem able to endure such water, but further out, along the fjord, where the water becomes more saline, it grows in the ordinary manner.

Of those species which grow by preference on *Fucaceæ, Elachista fucicola* and *Ulvella fucicola* may be mentioned. The first of these is the most important and often occurs in wonderful abundance, *Ulvella* forms a much less important part of the vegetation, more especially on account of its minute size.

Besides these two, other species frequently occur which just as often, or even more often, grow on other substrata. Of these *Pylaiella littoralis* plays a very important part in the vegetation, especially in the spring; then it sometimes occurs in such quantities that it almost covers large stretches of the coast. *Ulothrix flacca* also frequently occurs in great abundance, as may also be the case with *Isthmoplea sphærophora.* In spring and early summer *Ectocarpus tomentosus* and *Ectocarpus fasciculatus* are found growing together socially on *Fucus inflatus* (both of them in S. and SW. Iceland). *Ectocarpus confervoides* is also a rather frequent epiphyte. In addition, *Monostroma* and *Enteromorpha intestinalis* may be mentioned, on which, again, epiphytes can grow (as for instance *Chantransia*-species); also *Ulothrix pseudoflacca, Acrosiphonia, Ceramium rubrum, Ralfsia verrucosa, Conchocelis rosea, Porphyra umbilicalis* and others.

[1] Gertrud Tobler-Wolff, in Beihefte z. Botan. Centralbl., Bd. 24, 2. Abt., 1909.

It is usually the case that it is the older parts of the fronds which are most covered by epiphytes; this agrees well with the fact that the older fronds have a rougher surface than have the younger ones, and therefore retain the spores better. The epiphytes

Fig. 7. *Polysiphonia fastigiata* on *Ascophyllum* which is hanging on the face of the rock. Reykjavík, Aug. 13, 1909. (From phot. by Hesselbo.)

on the *Fucaceæ* do not appear to arrange themselves in strata as do the *Laminaria*-epiphytes.

The intermingled species do not play any special rôle in the *Fucus*-belt, as regards the vegetation; they consist partly of species which grow on the *Fucaceæ* and partly of species which ordinarily grow outside the *Fucus*-belt. Of these species the following may be mentioned: —

Monostroma Grevillei.	Cladophora rupestris.
Ulothrix flacca.	Acrosiphonia.
Monostroma groenlandicum.	Enteromorpha intestinalis.
Pylaiella littoralis.	Porphyra umbilicalis.
Chordaria flagelliformis.	Chætomorpha tortuosa.

The Under-vegetation. This is found commonly distributed, and varies considerably, both as regards luxuriance and the species composing it. The luxuriance seems to increase with the degree of exposure (except perhaps in the most exposed places), and then the composition of the species is also changed, as species which primarily belong to a lower belt extend higher up, probably on account of the frequent movements of the sea which cause the desiccation-period to last but a short time. The undergrowth must be regarded as a kind of shade-vegetation; during low-tide it is completely covered by the *Fucaceæ*, and at high-water the intensity of the light is also subdued by them, as they float on, or rise with, the water, and are moved backwards and forwards by its ripples. The greater part of the species of the undergrowth do not occur at the height of the *Fucus*-belt in places open to the light, but occur frequently and abundantly in shaded localities, although these may be found at the upper boundary of the *Fucus*-belt as, for instance, in depressions in the talus of debris, upon the under side of overhanging blocks of stone. This vegetation may therefore be justly termed the shade-vegetation of the littoral zone. The species are normally developed and cannot be compared with the shade-forms of light-plants belonging to the land-vegetation. On the other hand, the shade-vegetation of the littoral zone actually corresponds with the shade-vegetation of the land, such as the fern-vegetation and the liverwort-vegetation in the lava-fissures.

The under-vegetation belongs in part to the shade-vegetation (see p. 123) and is divided into several associations; here it is dealt with under the *Fucus*-belt as its strictly littoral distribution almost coincides with that of the latter, and it is just as dependent on the upper-vegetation, or even more so, as is the undergrowth in a coppice. As regards the relation between the upper-vegetation and the undergrowth in the *Fucus*-belt the main advantage is, I think with the undergrowth; although during low-tide, the upper-vegetation may gain some advantage from the fact that the layer of living plants under it retains more water than does the bare surface of the rock.

The following species of the under-vegetation occur in such quantities that they form associations of considerable extent which are usually pure, but may sometimes be mixed: —

Hildenbrandia rosea.[1]
Rhodochorton Rothii.
Sphacelaria britannica.
Polysiphonia urceolata.
Gigartina mamillosa.
Ceramium rubrum.
Callithamnion Arbuscula.

The *Hildenbrandia*-association is most extensively distributed, and is found everywhere along the coasts. It usually occurs as a pure association, though, in many places, *Verrucaria mucosa* is intermingled with it. *Hildenbrandia* may also occur at the same height outside the *Fucus*-covering, but is then — if the light is not subdued by other plants or projecting rocks — usually of a darker colour.

The Rhodochorton-association often covers extensive areas, like a dense, red carpet of felt. Most often it is pure, and appears, as far as its littoral distribution is concerned, to be confined mainly to the shady parts of the littoral zone. A few of the other shade-species may be found intermingled with it in small numbers, which fact is of minor importance, whereas the occurrence of the epiphyte *Pleurocapsa amethystea* is of great importance, as this species is found only on *Rhodochorton Rothii.*

R. Rothii does not occur below the *Fucus*-belt of the littoral zone until it occurs again at a considerable depth on *Laminaria* stems; thus it is found in two distant belts: the shade-belt of the littoral zone and the *Laminaria*-belt.

A Sphacelarietum *(S. britannica)* occurs almost quite pure in many places over rather large surfaces; it forms a dense covering on the rock as does *R. Rothii. Sphacelaria radicans, Polysiphonia urceolata* and *Rhodochorton Rothii* occur intermingled.

Polysiphonietum. *P. urceolata* occurs in a similar manner, covering rather large surfaces of rock. In places where the species forms extensive mats, it is usually very low in growth, yet always considerably higher than *Rhodochorton Rothii.* A thin layer of fine clay may often be seen to have accumulated between its basal parts.

A Gigartinetum occurs as under-vegetation, especially in more exposed places, and is then generally found in the lowest part of the *Fucus*-belt or in the *Fucus inflatus*-association; it is a direct continuation upwards of the *Gigartina*-association below.

[1] Arranged in accordance with the frequency, the most frequent coming first.

In addition Ceramieta formed by *Ceramium rubrum*, and Callithamnioneta formed by *Callithamnion Arbuscula*, occur distributed in patches, especially in the Vestmannaeyjar.

The following species, growing in a more scattered manner, occur also in the under-vegetation of the *Fucus*-belt: —

Delesseria alata. Plumaria elegans.
Lithothamnia.

The species of the under-vegetation thus belong principally to the red algæ; only two species being brown, one blue-green and one being a lichen. The majority of the species belong to the shade-vegetation of the littoral zone.

4. The Enteromorpha-association.

Of the *Enteromorpha*-species *E. intestinalis* is the most common and the most variable. The variability, no doubt, principally depends upon local conditions, possibly also, on the age of the species. The typical form is extremely common in the upper littoral zone, but occurs most luxuriantly in the water-filled depressions. As a rule, the plants have a social growth, although they rarely cover large areas. *E. prolifera* and *E. clathrata*, on the other hand, occur in such abundance that it might be justifiable to speak of an association formed of branching *Enteromorphas*. These species are found in greatest abundance in the middle littoral zone, often in empty depressions in the lower part of the *Fucus*-belt proper, and may sometimes extend beyond the boundary of the lower littoral zone, where they then encounter semi-littoral associations, for example, *Dictyosiphonetum, Chordarietum* and others. While the typical form of *E. intestinalis* seems to flourish during the spring, the branching forms *E. prolifera* and *E. clathrata* are noticeable in the summer. I have known these two species to occur predominantly in June, July and August on the same substratum upon which *Urospora Wormskioldii* was growing in great quantities in the month of May.

Enteromorpha Linza is also a summer species, and, although it forms in several places pure *Enteromorpheta* of lesser extent, plays only an inferior rôle in the *Enteromorpha*-association.

In E. Iceland, on the point between Seydisfjörður and Loðmundarfjörður, at the height of the lower part of the *Fucus*-belt and a little lower, I found a *Chlorophyceæ*-vegetation which must be considered to belong most nearly to this association. A Monostro-

metum of *Monostroma groenlandicum* was here found in abundance, often entirely covering the boulders and occurring on them, like *U. flacca*, closely pressed to the stone-surface with a radiating arrangement. In addition, an abundance of *E. intestinalis* f. *compressa* and a few *Ulothrix flacca* were found. A little lower down, a *Urosporetum (U. Wormskioldii)* occurred, which can scarcely be separated from this association; it seemed to form a connecting link with the semi-littoral communities.

Cladophora gracilis occurred intermingled in the *E. clathrata*-association, yet without playing any important rôle in the vegetation.

A similar association, especially an *Enteromorphetum* of *E. intestinalis*, is, beyond doubt, very common in other countries. It seems to be more poorly developed in Greenland (Rosenvinge, 63, p. 205) than in Iceland; in the Færöes (Börgesen, 12, pp. 714, 715), on the other hand, the *Enteromorpha intestinalis*-vegetation seems to be more luxuriant than in Iceland.

5. The Acrosiphonia-association.

This association consists of decidedly filiform, much branched algæ, which grow very socially. During the period of desiccation they retain the water as a sponge retains it. This circumstance is mentioned with regard to some of these species by Rosenvinge (63, p. 202), who says of *Cladophora arcta* (= *Acrosiphonia incurva*, cf. Jónsson, 32, p. 43) that in Greenland it behaves during low-tide like a sponge saturated with water.[1]

The principal species in this association are *Acrosiphonia albescens* and *A. incurva*. They form individually, pure *Acrosiphonieta* in the upper and lower littoral zones, where they cover flat stones with a densely matted vegetation. On flat rocks the association may be somewhat widely distributed, in other places it has more the character of scattered *Acrosiphonieta*. The density of the vegetation is due to the structure of these species. As the basal part of the principal axis is too weak to carry the plant when its branch-system has developed, lateral rhizoids, which slope downwards, are developed at an early stage from the principal axis itself and from the lower branches. These rhizoids often form creeping filaments from which arise erect shoots, which can be detached from the parent-plant and thus become independent individuals. The principal

[1] Possibly this is the case in an even higher degree with *Callithamnion Arbuscula* (cf. Börgesen, 12, p. 726).

axis dies away from below and in this way branches, or systems of branches, with well developed rhizoids are detached from the parent-plant and become independent individuals (cf. Jónsson, 32). The rhizoids of one individual become entangled with those of others, and in this way the basal parts of the entire vegetation become matted together. In addition to this, the lower branches are hook-shaped, or bent downwards and outwards; thus it easily happens that they are entangled between the branches of other individuals, which further increases the matted condition. The upper branches are directed obliquely upwards, without being entangled with the branches of other individuals.

An *A. albescens*-association occurs everywhere along the coasts, but on very exposed coasts the species generally grows dispersed. Here it occurs in separate tufts which are, no doubt, composed of several individuals, densely matted together below, but branching upwards in various clusters, which are themselves densely matted together by their hook-shaped branches; the branch-systems above are, as usual, free. These characteristically matted branch-clusters are probably an effect of the heavy beat of the waves; the matted *Acrosiphonia* "tufts" will not be able to resist the force of the waves and, even at an early stage, will become divided into very densely matted branch-clusters.

Acrosiphonia albescens occurs both in the upper and the lower littoral zone, while *A. incurva* belongs to the lower littoral zone, but yet also extends upwards into the pools of the upper littoral zone, and below low-water mark.

Spongomorphetum. *Spongomorpha vernalis* grows very socially, but never forms such a dense vegetation as does *Acrosiphonia*, although it is sufficiently dense to characterize the spot. The species has been found in only a few places; it occurs in abundance at Grótta, where it grows both on a stony substratum and also as epiphytic vegetation in the *Corallina-Gigartina*-belt and in the *Polysiphonia urceolata*-association of the lower littoral zone.

A Cladophoretum formed of *Cladophora sericea* f. (see under Tide-Pools) also belongs to this association. It forms a densely matted belt in pools high up in the upper littoral zone. As a rule it follows the edge of the water round the entire pool.

Cladophora rupestris ought also to be considered to belong to the *Acrosiphonia*-association.

An association similar to the *Acrosiphonia*-association is, no

doubt, very common in adjacent lands. During low-tide the uppermost free branches appear to be more exposed to desiccation and possible death in Greenland than in Iceland; in the latter place it occurs rather frequently. Both in Greenland (Rosenvinge, 63) and in the Færöes (Börgesen, 11, 12) the *Acrosiphonia*-association is well represented.

bb. The Shade-vegetation.

To this vegetation are referred certain littoral associations which occur exclusively in shady places. The shade is produced by the light being subdued both by a covering of living plants and by projecting blocks of stones. Thus the greater part of the under-vegetation-associations of the *Fucus*-belt mentioned above belong to the shade-vegetation. In addition, the shade-vegetation grows, as already mentioned, on the under side of overhanging rocks — on their in-sloping sides. The vegetation is divided into several associations which have already been mentioned in connection with the under-vegetation of the *Fucus*-belt (cf. p. 118).

The frond differs in form and structure in the various species of this vegetation. It is a feature common to the whole of the shade-vegetation to be low and dense in growth. The frond of *Hildenbrandia* is a crust which covers the rocks; the others are finely branching; some, as *Sphacelaria* and *Polysiphonia* are bush-like and are richly and finely branched; *Rhodochorton* has a similar mode of branching, but to a considerably less degree. These three species often propagate vegetatively by means of runners, which increases the density of the vegetation. *Plumaria* is closely and distichously branched; it is tightly adpressed to the surface of the stones during the time of low-tide and retains much water between its branches, considered from a biological point of view it might almost be regarded as leaf-like during the period of desiccation.

6. The Hildenbrandia-association belongs almost exclusively to the under-vegetation of the *Fucus*-belt, and of the shady localities in the littoral zone (see above, p. 118).

7. In shady places the Rhodochorton-association, the Sphacelarietum britannici, and the Polysiphonietum urceolatæ behave in a similar manner outside the *Fucus*-belt as they do within it (see above). They may occur either as pure as-

sociations, and are then dominant here and there in patches, or the species may be found intermingled with each other. Besides these associations a Plumarietum, consisting exclusively of *Plumaria elegans,* is found in many places. This association is darker in colour than the other red-algæ associations of shady places; it occurs frequently in S. and SW. Iceland. Intermixed in it occur *Callithamnion scopulorum* and *Chantransia virgatula.*

Rhodochorton Rothii is sometimes found high up in the littoral zone on flat rock-surfaces exposed to the light and to the beat of the waves, but then it grows in small globular cushions *(f. globosa).* Consequently, this globetum of *Rhodochorton Rothii* does not belong exclusively to the shade-vegetation.

On flat surfaces in the shade the usual arrangement is that the decided shade-associations occur at the bottom, where the light is feeblest, e. g. the *Sphacelarietum, Rhochortonetum, Polysiphonietum, Plumarietum;* at the top, where the illumination is stronger, light-loving species occur, e. g. *Pylaiella, Ulothrix,* or others. Near Reykjavík a vertical section of such a surface showed uppermost, at the edge, *Pylaiella littoralis,* next *Rhodochorton Rothii f. globosa,* and lowest of all *Plumaria elegans.*

In a grotto in the Vestmannaeyjar, where the illumination was very feeble, *Enteromorpha intestinalis f. micrococca* occurred on the roof, *Ceramium acanthonotum* grew rather high up on the walls, and *Plumaria elegans,* together with *Delesseria alata,* formed a belt lower down the walls.

A vegetation corresponding to the shade-vegetation appears to occur in Greenland where *Hildenbrandia rosea, Ralfsia clavata* and *Verrucaria mucosa* form the undergrowth in the *Fucus*-belt and in other places (Rosenvinge, 63, pp. 198 and 203). *Rhodochorton Rothii* and *Sphacelaria britannica* also appear to grow in a similar manner in Greenland (Rosenvinge, 63, p. 205).

A comparison with the Færöes shows some difference. The vegetation in the grottoes in the Færöes (Börgesen, 12, p. 739), however, resembles in its main features the Iceland shade-vegetation, and, in addition, a similar vegetation is beyond doubt to be found in fissures and clefts of the rocks in the Færöes, but the mode of occurrence of the species is not the same. Thus, in the Færöes (Börgesen, 12, p. 711), the *Hildenbrandia*-association appears to have a much wider distribution upwards and to occur in fully illuminated localities. *Rhodochorton Rothii* seems to occur in a similar manner

in the Færöes (Börgesen l. c., p. 718) as it does in Iceland, with this difference, however, that the species extends higher upwards in the Færöes and, also, frequently grows in fresh-water in the latter place.[1] *Sphacelaria britannica* grows similarly in the Færöes (Börgesen, 13, p. 432).

According to Foslie (18) a similar shade-vegetation appears to occur in northern Norway.

This vegetation is a natural upward continuation of the semi-littoral *Polysiphonia urceolata*-association mentioned below.

cc. The Vegetation of Tide-Pools.

Where there is a rocky coast, depressions of varying sizes occur everywhere in the littoral zone. These depressions may be divided into two groups: The tide-pools of the upper littoral zone, and the tide-pools of the lower littoral zone. The plant-growth in these tide-pools does not form a vegetation-unit, and is chiefly composed of species either scattered or of social growth which belong to the littoral or semi-littoral communities; they are, however, here treated separately in order to further characterize the illustration of the littoral zone given in the above description.

Tide-Pools of the Upper Littoral Zone. Of these the uppermost, which are almost on the level of *Fucus spiralis*, are of the greatest interest, as they often contain species, or forms of species, which do not occur elsewhere in the littoral zone. These species are *Cladophora sericea* f. and *Fucus inflatus* f. *linearis*.

The water in the uppermost pools is not replenished with the recurrence of each high-tide, and this is especially the case in calm weather during neap-tide; if, simultaneously, dry weather occurs, the water evaporates, and this the vegetation cannot endure for any length of time. In rainy weather, on the other hand, the pools are filled with fresh water, and should this happen during neap-tide the salinity would be insufficient for any of the species to exist. At spring-tide the water in the pools becomes mixed with a fresh supply of sea-water, and the vegetation then lives, for a time, under good conditions. Thus, there are times during which the conditions in the pools are not favourable to algal life.

Cladophora sericea grows very socially in many places and, in

[1] When I visited the Færöes in October, 1897, I was at first surprised to find *R. Rothii* growing in streams at and above the upper limit of flood-tide; such a situation for it in Iceland was unknown to me.

small pools, often forms a continuous fringe, the upper branches either reaching to or lying on the surface of the water. In such pools *Chætomorpha tortuosa* sometimes occurs in fair abundance loose upon the surface of the water; its filaments are usually densely matted together.

Fucus inflatus f. *linearis* grows even more socially. At times it is almost the dominant species in the smaller pools, although, rather frequently, several other species are found intermingled with it. This form is a biological variety of *Fucus inflatus* which, in the pools, exists evidently under less favourable circumstances; this is one cause of its small size and feeble structure, although another is that it is not exposed, to any extent worthy of mention, to the beat of the waves. Rosenvinge has especially shown this to be the case as regards Greenland. Rosenvinge explains the frequent occurrence of this form in the pools by the fact that the eggs of *F. inflatus* are carried into the water-filled depressions by the movement of the water and accumulate there. This explanation is undoubtedly correct, and, as Rosenvinge points out, all intermediate stages between the feeble pool-form and the typical form can be demonstrated. To any one who has seen this endless variation in nature, it seems so certain that it is due to the influence of outside factors, that experimental proof is almost superfluous.

The uppermost pools are generally extremely poor in species; and, besides those already mentioned, only *Enteromorpha intestinalis* occurs in any great abundance. Where the coast is exposed, the uppermost pools may, however, have a resemblance to the lower ones of the upper littoral zone — a natural consequence of the exposure. On more exposed parts of the coast a fringe of small *Monostroma Grevillei* is often found, almost on the surface of the water itself. At one place in E. Iceland I took the temperature of such a submerged plant-covering, and the thermometer showed 20° C. (June 13). The vegetation was also somewhat injured, and evidently did not prosper under these conditions.

High up on a rocky coast to the south of Vattarnes in E. Iceland, I came across a pool-vegetation. I did not measure the altitude of the spot, but I do not think that I was greatly mistaken in estimating it at 70—100 feet above sea-level. As regards the place, I noted in my dairy — "High rocky coast, land-plants grew round the alga-pools. The water in the pools must be replenished with rain and heavy surf, which sometimes fail for long periods during

the summer. Many pools filled with decaying and dying algæ." The occurrence of algæ so high up can be imagined only on a very exposed coast facing the open sea, and even there it would be exceptional.

The dominant species of the vegetation in these high-lying pools consisted of *Fucus inflatus* f. *linearis*. Intermixed occurred *Chætomorpha Melagonium* — which I never before had seen so high above sea-level — *Acrosiphonia* sp., *Dictyosiphon foeniculaceus*, *Pylaiella littoralis* and *Enteromorpha intestinalis* f. *typica*. The undergrowth consisted of *Hildenbrandia rosea*.

In another somewhat elevated and exposed place in the vicinity of Vattarnes, a number of small pools were found just below the *Verrucaria maura*-belt. *Hildenbrandia* and *Verrucaria mucosa* grew on stones at the bottom of these pools; in addition, *Fucus inflatus* f. *linearis* occurred fairly abundantly, although dying in the pools, which were deficient in water.

The lower pools in the upper littoral zone have a much more luxuriant vegetation. Here various littoral and semi-littoral species can grow in fair abundance. The water in these pools is replenished at each high-water, so here, the plants exist under fairly favourable conditions. The following species may occur dominantly or abundantly: — *Fucus inflatus* f. *linearis*, *Halosaccion ramentaceum*, *Monostroma fuscum*, *Enteromorpha intestinalis*, *Monostroma Grevillei*, *Dictyosiphon foeniculaceus* and *Castagnea virescens*.

Many species are found growing scattered, of which the following are most frequently met with: —

Polysiphonia urceolata.
Porphyra miniata.
Rhodomela lycopodioides.
Rhodymenia palmata.
Chorda Filum.
Chordaria flagelliformis.
Coilodesme bulligera.[1]
Ectocarpus confervoides.
Elachista fucicola.
Phyllitis fascia.
Pylaiella litoralis.
Scytosiphon Lomentaria.
Chætomorpha Melagonium.
C. tortuosa.
Cladophora gracilis.
Monostroma undulatum.
Ulothrix flacca.
Urospora Wormskioldii.

The under-vegetation often consists of *Ralfsia deusta*, *Lithothamnion circumscriptum* and *Hildenbrandia rosea*.

Taken on the whole, the majority of the littoral species undoubtedly may be met with in the pools, and it should be especially

[1] It may be observed, as regards *Coilodesme*, that it is the more inflated the lower the water is in the pools.

noted that, when the semi-littoral species occur in the upper littoral zone, they are usually confined to the pools, a fact which proves that they do not essentially belong to the upper littoral zone.

b. The Semi-littoral Zone.

The upper boundary of this vegetation is just at the lower boundary of the *Fucus*-belt. The vegetation covers the lower littoral zone, and extends, usually in the form of stragglers, below the limit of low-tide, down between the uppermost extensions of the vegetation of the *Laminaria*-belt, which in many places reach right up to the limit of low-tide. The semi-littoral communities consequently grow side by side with the *Laminaria*-associations below the limit of low-tide, to a depth of about 10 metres; they also occur as epiphytic vegetation on the *Laminariæ* at the depth mentioned.

Thus, the semi-littoral zone is that between the lower edge of the *Fucus*-belt and the *Laminaria*-belt. The breadth of the zone depends on the slope of the coast. If the coast is steep the zone is narrow, but if the coast slopes gently, it is broad. In this zone no single dominant community of extremely social and large species occurs, like, for example, the *Fucaceæ*-community in the littoral zone, and the *Laminariaceæ*-community in the sublittoral zone. The zone appears to lie too low for *Fucaceæ* and too high for *Laminariaceæ*.

Green and brown algæ occur in abundance in the semi-littoral zone, but the *Rhodophyceæ* are most richly represented. The semi-littoral associations occur both laid bare during low-tide and also continuously submerged to the depth mentioned.

It is easy to follow the upper boundary of the zone, even in places where the *Fucaceæ* are absent. The lower boundary can also be ascertained with comparative ease, if the large *Laminariæ* only are followed, and if the observer is not led astray by the small *Laminariæ*, which may occur in the depressions and pools of the lower littoral zone.

The semi-littoral zone comprises several associations which play a rather considerable part in the vegetation.

By authors who describe the algal vegetation on coasts where there is a change of tide these associations are generally considered to belong partly to the littoral and partly to the sublittoral vegetation. On coasts where there is no tide, the littoral vegetation has,

however, been subdivided. Reinke (58, p. 10) divides the littoral region near Kiel into an upper zone which is always laid bare at low-water, and a lower zone at a depth of 2—4 metres. So far as I can judge from the species enumerated, Reinke's upper zone corresponds approximately with the previously mentioned upper littoral zone, while the lower zone corresponds only in part with the semi-littoral zone here described. Gran (24, p. 11) records under the term "sublittoral vegetation" transitional formations which evidently, for the most part belong to the semi-littoral communities.

On the west coast of Sweden (Kylin, 45) the border-line between the littoral and sublittoral algal vegetations is, on the coast of Bohuslän, at a depth of 3—4 metres, and at Halland at a depth of about 5 metres. The upper part of the littoral zone seems to correspond to some extent with the above-mentioned upper littoral zone, while the lower part has something in common with the semi-littoral zone.

Where there is no tide, the boundary between an upper and a lower littoral zone is not, I think, so sharply defined.

8. The Monostroma-association.

This vegetation is composed of relatively large, membranaceous, green algæ. *Monostroma fuscum* and *M. Grevillei* form associations in a rather considerable number of places in protected localities in the fjords, below the limit of low-tide, and to a depth of at least 4—6 metres. There, the association is most sharply defined, although it is fairly frequently found intermingled with other semi-littoral associations. In the lower littoral zone also, an abundant *Monostroma*-vegetation frequently occurs, both on a rocky substratum, and also very often as epiphytic vegetation in other associations, as, for example, the *Halosaccion*-association, the *Corallina*-association, the *Polysiphonia urceolata*-association and others. In water-filled depressions in both the upper and lower littoral zone the *Monostroma* species often occur abundantly.

Monostroma Grevillei var. *arctica* seems to belong more immediately to the littoral zone. In many places it is found entirely laid bare, sometimes on a clayey substratum, when it often attaches itself to small individuals of *Mytilus edulis*, and sometimes where the substratum of the littoral zone is pebbly. During April and May this vegetation is rather characteristic, because then, the species occurs for the greater part in the inflated stage. The bladders vary

greatly in size and form and may be at times considerably elongated, bearing then a striking resemblance to an *Enteromorpha*. Under calm conditions the inflated stage continues until the spores at the apex of the frond are ripe.

In several places in the fjords *Monostroma Grevillei* var. *typica* forms a luxuriant, characterizing vegetation at a depth of about 3—5 metres.

Monostroma fuscum very frequently forms associations of considerable extent in the fjords at a depth of about 4 metres. The specimens of this species which occur there are generally very large *(f. grandis)*. These large specimens are rather frequently found at low-water mark, detached or floating at the water's edge, and then it may generally be taken for granted that a *Monostrometum* exists further out at a depth of about 4 metres.[1] Both in the fjords of E. Iceland and in Eyjafjörður in N. Iceland this *Monostrometum* occurred in the same characteristic manner, viz. alternating with a *Chordarietum*, a *Dictyosiphonetum (D. foeniculaceus)*, a *Halosaccionetum*, and a *Rhodymenietum*. Generally the order was that *Rhodymenia* grew deepest (as deep as 12 metres), and *M. fuscum* most frequently uppermost (at about 4 metres). *Alaria* and *Laminaria saccharina*, in addition, may be found growing scattered in such places, which makes the character of the vegetation still more heterogeneous.

Monostroma undulatum does not occur so abundantly as do the other *Monostroma* species. It is found growing rather luxuriantly, however, in pools in the lower littoral zone, and on the stems of *Laminaria* in comparatively low water.

Ulva Lactuca, also, is most nearly related to this association.

This association is very common in the Færöes (cf. Börgesen, 12, pp. 731 and 764), and occurs also in Greenland (Rosenvinge, 63).

9. The Chorda-association.

This association is composed of rather large, brown algæ. The fronds are either non-branching, thick filaments *(Chorda, Scytosiphon)*, or else branched, as in almost all the others; one, *Coilodesme*, however, is almost leaf-like.

This association has an insignificant distribution, and is found usually in patches, where the substratum is clayey or somewhat muddy. It occurs both in the lower littoral zone above low-water mark, and to a depth of at least 4—6 metres. The members of the

[1] Strömfelt (70, p. 11) mentions this *Monostrometum* at Eskifjörður.

association are as follows: — *Chorda Filum, C. tomentosa, Chordaria flagelliformis* and *Dictyosiphon foeniculaceus. Scytosiphon Lomentaria, Castagnea virescens* and *Coilodesme bulligera* are also most nearly related to this association. Some of the species occur in such abundance that they may be said to form an association; this applies more particularly to *Chorda Filum.* A pronounced *Chorda Filum*-association occurs in many places at a depth of almost 3—4 metres (measured during low-water of spring-tide). The individuals are extremely long, about 6 metres and, to a great extent, float on the surface at low-tide. The substratum is, as a rule, clayish with pebbles here and there. This association is often almost pure, but scattered individuals of *Laminaria saccharina* are not rare, although they play no essential rôle in the vegetation. *Chorda Filum* also grows above low-water mark in the lower littoral zone, but there it does not really form associations, although it may grow luxuriantly in many places.

Chorda tomentosa is also social and grows more luxuriantly below low-water mark than above it. It often occurs in abundance as a component of the sublittoral vegetation.

Chordaria and *Dictyosiphon foeniculaceus* are species which grow socially, and rather frequently a *Chordarietum* or a *Dictyosiphonetum* is found, usually with a limited distribution both below low-water mark and above it, especially in water-filled depressions in the littoral zone. The remaining species which have been mentioned are also of rather social growth in many places, both below and above low-water mark, especially in pools. *Coilodesme,* for example, was rather frequent in tide-pools in E. Iceland, and sometimes at a very high level, but then the individuals were frequently inflated; in SW. Iceland the species grew at and below low-water mark in company with *Chorda Filum* and *Saccorrhiza.*

With the exception of the above-mentioned *Chorda Filum*-association, this vegetation occurs usually in patches, distributed between other associations. Thus it is closely connected with the *Enteromorpha clathrata*-association at the boundary between the upper and lower littoral zones, and with the *Rhodymenia*-association and the *Monostroma fuscum*-association at a depth of about 4 metres, as has been previously mentioned.

In the Færöes a similar vegetation occurs as a part of the *Stictyosiphon*-association (Börgesen, 12, pp. 762—763).

10. The Community of Rhodymenia.

The species are *Rhodymenia palmata* and *Halosaccion ramentaceum,* both of which occur along the coasts in great abundance as pure associations. These two associations most frequently accompany each other, and seem to demand somewhat similar conditions of life. *Halosaccion,* however, extends the higher up in the littoral zone, but is then almost always submerged in water-filled depressions in that zone, while *Rhodymenia* extends the further down below the limit of low-tide. In *Rhodymenia* the form of the thallus is leaf-like and branching; in *Halosaccion* it is round and excessively or slightly branching.

The Rhodymenia-association. On regarding a steep rocky coast, where the succession of the associations is always most easily observed, it is seen that a luxuriant *Rhodymenia*-vegetation commences even at the lower boundary of the *Fucus*-belt. In many places the species occurs so socially that it predominates as a characterizing plant over relatively large stretches, both in the lower littoral zone and far below the limit of low-tide, to a depth of about 12 metres. On a gently sloping rocky coast, the upper boundary of the association is not so sharply defined, but if proper allowance is made for the depressions and elevations in such a littoral zone the boundary is fairly easily ascertained although it may then lie in very many curves. On a gently sloping pebbly coast, the same regular boundary is found as on a steep rocky coast and at about the same height, although the *Fucaceæ*-community is not present there.

Various algæ may occur on stones under the fronds of the *Rhodymenia,* as, for instance, *Hildenbrandia rosea, Ralfsia clavata, Sphacelaria radicans* and others; also a number of epiphytes, especially *Myrionemaceæ* and *Ectocarpaceæ,* often grow on old individuals of *Rhodymenia palmata.*

Rhodymenia occurs also epiphytically on the stems of *Laminaria* in the upper part of the *Laminaria*-belt.

The *Rhodymenia*-vegetation does not seem to be so luxuriant in Greenland (Rosenvinge, 63) as in Iceland. Possibly this is true also of the north of Norway (Foslie, 18). In the Færöes the *Rhodymenia*-vegetation is luxuriant, but seems to differ somewhat from that of Iceland, as it consists of a form with lower and more dense growth and narrower branches; this form also extends further up (Börgesen, 12, p. 727).

The Halosaccion-association also commences below the lower boundary of the *Fucus*-belt, and extends from there to a depth of about 5 metres below low-water mark. The species grows very socially, entirely covering the rocky substratum upon which it grows; it is very variable, and, while *f. densa* seems to extend rather high up, in pools in the littoral zone, it is *f. robusta* which, as a rule, reaches to the greatest depth. *F. subsimplex* is very common just below the *Fucus*-belt, where it grows so densely that it covers the substratum completely. It is very often interwoven with byssal-threads of *Mytilus edulis*. In this form, as in the laid-bare *f. robusta*, inflated shoots occur fairly frequently. As is the case with *Rhodymenia palmata*, this species is very frequently decoloured in the lower littoral zone; yet in both species the lower part of the frond is, as a rule, reddish in colour.

Of the epiphytes, *Elachista fucicola* is especially frequent, and various other species may also occur closely applied to *Halosaccion*, such as *Porphyra miniata*, *Monostroma fuscum*, *M. Grevillei* and others. At times the *Monostroma* species may be so abundant that they may be said to play a distinct rôle as epiphytic vegetation. Among the *Halosaccion* individuals, *Dumontia filiformis*, *Chætomorpha Melagonium* and others often occur growing scattered at the very limit of low-tide.

A similar Halosaccion-vegetation occurs in northern Norway (Foslie, 18), and probably on the arctic coasts as well (Kjellman, 36; Rosenvinge, 63). In the Færöes the association is poorly represented (Börgesen, 12, 13).

11. The Polysiphonia urceolata-association.

At and about low-water mark in the lower littoral zone, an association is found consisting principally of excessively branching, red algæ which I will name after the species *Polysiphonia urceolata*, which is dominant in the association. This vegetation frequently occurs on a flat or convex substratum of rock (lava-substratum) and often forms, especially in SW. Iceland, for example at Grotta near Reykjavík, a broad belt around *Corallina*-pools, near low-water mark.

The species which occur in greatest abundance in this association are *Polysiphonia urceolata*, *Cystoclonium purpurascens* and *Rhodomela lycopodioides*.

The Polysiphonia urceolata-association is very luxuriant

in many places at about low-water mark, and often covers rather large stretches of rock with a dense but, at times, low vegetation. As previously mentioned, it grows luxuriantly on flat rocks, without any protection whatever during the period of exposure, which is certainly short, and indeed exceedingly short during a heavy sea. Here, as in the upper littoral zone, the association occurs also on the face of the rocks, and the species seems as a rule to be larger than when on flat rocks. The association appears to have an extended vertical distribution since, as previously mentioned, it occurs as shade-vegetation or undergrowth in the upper littoral zone; furthermore it must be assumed that it has a larger sublittoral distribution than is shown by the dredgings, as it has been found outside the 10-metre contour (see below). From what I have seen, the stretch of shore just above and somewhat below low-water mark is essentially the home of this association. It usually grows on a rocky substratum and on *Laminaria* stems at no great depth.

Cystoclonium purpurascens grows socially in many places both on a rocky substratum and on *Gigartina*. Sometimes it occurs in such abundance as an epiphytic vegetation in the *Gigartina-Corallina*-belt, that it is the alga which characterizes the vegetation, and not until the plants are moved aside is it seen that they are attached to a living substratum. On *Cystoclonium* various epiphytes occur, for example, *Chantransia, Monostroma Grevillei* and others.

Rhodomela lycopodioides very frequently grows scattered, and then plays only an insignificant rôle in the vegetation; but *Rhodomeleta* of limited extent also occur, often in contact with the *Polysiphonia urceolata*-associations.

Ceramium rubrum, C. acanthonotum and Callithamnion Arbuscula really belong to this association. In many places these species grow fairly socially and *Ceramieta* of *C. rubrum* and *C. acanthonotum* and *Callithamnioneta* of limited extent occur both on rocky substrata and on one of *Gigartina;* however, I think that these species occur too sparsely to be termed association-formers.

Sphacelaria radicans also belongs to this association. Often, even at low-water mark, it covers flat stones with a dense vegetation, but though these small *Sphacelarieta* are considerably distributed, yet they cannot be called associations.

In the Færöes a similar *Polysiphonia urceolata*-vegetation occurs (Börgesen, 12, p. 731).

12. The Community of Corallina.

The members of this community are *Corallina officinalis, Gigartina mamillosa, Chondrus crispus* and *Ahnfeltia plicata*. These species occur as a rule in luxuriant and more or less sharply defined associations, which very frequently occur together, and may therefore be regarded as nearly related to each other.

The fronds are branched, and their consistency is on the whole firm because, as is known, *Corallina* is encrusted with calcium carbonate, *Ahnfeltia* is horny and *Gigartina* and *Chondrus* are cartilaginous.

Gigartina and *Corallina* generally occur in a belt at the limit of extreme low-water; in my diary I have always called this belt the *Gigartina-Corallina*-belt. *Gigartina,* however, extends higher up; on exposed coasts right up to the *Fucus*-belt, and even into that as under-vegetation; but, where *Gigartina* and *Corallina* meet, there is most frequently a mixed belt. These associations belong to S. and SW. Iceland.

The *Corallina*-association occurs most luxuriantly about low-water mark. The species grows extremely socially, and entirely covers depressions in the littoral zone which are more or less filled with water. The association occurs on somewhat exposed and also on very exposed coasts, but almost always in depressions surrounded by rocks upon which the waves break; yet I have seen it, where the exposure is but slight, covering the face of rocks below low-water mark. Only rarely have I obtained *Corallina* by dredging in greater depths, as, for example, on the north coast, at a depth of about 14 metres, where it seems to be present in abundance. It may be assumed with certainty, however, that this association has a much wider distribution below the limit of low-tide than is shown by the dredgings, and with exceptional low-tides it can be seen that in many places the *Corallina*-vegetation covers the rocks as far as the eye can reach.

On a very exposed coast I have met with *Corallina* growing socially in water-filled depressions at a considerable higher level, sometimes on a level with the upper part of the *Fucus*-belt. Here, however, with the exception of the lowest part of the frond, it is quite white in colour, and has evidently strayed outside its real domain. The spores have been carried to this height above the true *Corallina*-belt by the beat of the waves, and have been retained in the depressions. It can also thrive fairly well at this height during

the autumn and winter, both because the light is feeble, and because the increased high seas following stormy weather to some extent compensate for the difference in height. But it is in the spring and summer that it is most evident that *Corallina* has really extended too high up. According to Börgesen's description (12) it appears to extend still higher up in the Færöes.

In the *Corallina*-association an abundant epiphytic vegetation may occur, both of small algæ like *Chantransia* and of larger algæ such as *Monostroma Grevillei, Spongomorpha vernalis, Acrosiphonia albescens* and also the *Leathesia*-associations. Furthermore, *Ceramium rubrum, Cystoclonium, Delesseria sinuosa* and *D. sanguinea* occur, and other red algæ, often in great quantities. When to this is added the fact that *Gigartina* is often abundantly intermingled with those already mentioned, it is easily seen that this mixed vegetation assumes quite a different character, according as to whether the brown-red *Gigartina* and *Ceramium* or the light-green *Monostroma* and *Spongomorpha* predominate. This characteristic appearance differs entirely from the usually monotonous appearance of the *Corallina*-belt. This epiphytic vegetation must be considered to form associations which do not really belong to the *Corallina*-vegetation in any other respect than that of having it for a substratum.

The Gigartina-association is widely distributed on very exposed coasts; it often is of very great breadth and, as already frequently mentioned, extends in under the *Fucaceæ* as undergrowth. Where the exposure is less, it does not reach so high; but yet, in the lower littoral zone there is, as a rule, a distinct *Gigartina*-belt, which most frequently occurs above the limit of low-tide. The *Gigartina*-vegetation extends also below the limit of low-tide, but it seems to belong most closely to the lower littoral zone. The belt is quite characteristic, and can often be seen from a distance, as the colour is in strong contrast to that of the *Fucaceæ*-community. The species is of very social growth and is usually dominant where it occurs; not rarely, however, a few species occur intermingled with it, especially in the Vestmannaeyjar and at Öndverðarnes, two very exposed localities. In the *Gigartina*-belt *Corallina* may occur lowest, *Callithamnion Arbuscula* is sometimes plentifully intermixed with the *Corallina* and occurs also in abundance as an epiphyte, and *Ceramium acanthonotum* occurs rather frequently and often abundantly. In the Vestmannaeyjar *Callithamnion scopulorum* occurs rather frequently as undergrowth. In addition, *Ceramium rubrum,*

Delesseria alata, Acrosiphonia, Polysiphonia urceolata, Plumaria elegans and *Rhodymenia palmata* occur. *Porphyra umbilicalis* occurs as an epiphyte in the Vestmannaeyjar, and also *Cystoclonium, Polysiphonia urceolata* and others.

The *Gigartina*-belt is very luxuriant in the Vestmannaeyjar and at Öndverðarnes; it may be said to be, on the whole, luxuriant in S. and SW. Iceland. As regards the relations between *Gigartina* and *Corallina,* the following observation from the Vestmannaeyjar may be recorded. At Brimsurð, on the south-east side of the inhabited island, where the littoral zone consisted of large, although not particularly high boulders, these were entirely covered above by a dense *Gigartina*-vegetation, while *Corallina* formed just as dense a belt around them below.

Chondrus crispus also grows socially in S. and SW. Iceland. It is true that *Chondreta* of lesser extent occur usually at or near low-water mark, but nowhere does the species occur nearly as luxuriantly as does *Gigartina.* The *Chondrus*-vegetation is most luxuriant in the Vestmannaeyjar and at Eyrarbakki. Between the skerries off the latter place, the broad-fronded form grew in abundance, both above and a little below the limit of low-tide. In both the places mentioned, which belong to S. Iceland, it grows in such abundance that the vegetation might almost be termed an association; in SW. Iceland on the other hand, it seems to occur more sparsely, and the small *Chondreta* may then be considered to belong to the *Gigartina*-association.

Ahnfeltietum. *Ahnfeltia plicata* grows socially in S. and SW. Iceland and usually forms a narrow belt at and below the limit of low-tide. The individuals are very frequently matted together by the byssal threads of various small molluscs, and worms and quantities of snails are found between the plants. In reality this vegetation is more nearly related to the *Corallina*-association than to the *Gigartina*-association. This species grows also scattered among *Corallina* and *Gigartina.*

The intermingled species are only few in number, for example, *Ralfsia deusta* which may occur abundantly in small depressions, and *Leathesia difformis* which sometimes occurs in abundance as an epiphyte. *Ahnfeltia* is most frequently decoloured above low-water mark.

Chætomorpha Melagonium occurs rather frequently, grow-

ing scattered in the *Corallina-Gigartina*-belt, without playing any further part in the vegetation.

The Leathesia-association is here mentioned in connection with the *Corallina-Gigartina*-belt. The brown, spherical, cartilaginous *Leathesia difformis* is found in abundance in this belt only, and I prefer to mention it here rather than to place it in the *Chorda*-association. The species occurs only as an epiphyte, not only on *Ahnfeltia* but also on *Corallina, Gigartina* and *Chondrus,* and is often wonderfully numerous. The size varies greatly, often the globules may be rather large and, by their yellowish colour greatly alter the appearance of the vegetation. It often almost entirely covers rather extensive *Corallineta.* The species is a summer-form, which does not occur in any quantity worthy of mention until the month of June, flourishes during July and August, and disappears in September, at any rate in SW. Iceland.

Small specimens of *Leathesia* occur also on *Rhodymenia palmata.*

13. The Crustaceous alga-association.

At low-water mark and in the lower littoral zone, there occurs a crustaceous algal vegetation which may be considered a direct continuation of the sublittoral crustaceous algal vegetation (see below, p. 148). Here, the species are, for the most part, the same, e. g. *Lithoderma fatiscens* and *Lithothamnion compactum.* Both these species often have a somewhat considerable distribution in the lower littoral zone. The *Hildenbrandia*-association mentioned as existing in the upper littoral zone also occurs here. *Lithothamnion lœve* and *Phymatolithon polymorphum* also occur in the lower littoral zone. In addition, we have *Ralfsia deusta* which, in many places, forms patches upon the bottom of pools in the lower littoral zone, and plays rather an important rôle in the vegetation.

Tide-Pools of the Lower Littoral Zone are most frequently depressions which are either directly connected with the part which is constantly submerged or separated from it by a ridge; which may happen to be the case is unimportant as the period of exposure in this part of the littoral zone is extremely short, as is also seen from the fact that the vegetation in these depressions consists of sublittoral associations, or more correctly, of stragglers from them. Thus, *Laminaria* and *Alaria* species frequently occur in

these depressions which fact will be mentioned again later on. Some of the depressions are occupied by semi-littoral associations, thus, *Corallineta, Gigartineta, Chondreta, Monostrometa, Ceramieta*, etc. frequently occur, and, in addition, several of the species which belong to these associations are found growing in a scattered manner.

As mentioned above (p. 125), the vegetation in the pools is highly heterogeneous, and, in the large pools it can frequently be seen that the associations or their representatives arrange themselves in belts, here on a small scale in the same manner as they do on a larger scale outside the pools.

c. The Sublittoral Zone.

The sublittoral vegetation covers the sea-bed from the limit of low-tide down to a depth of 40—60 metres, and perhaps to an even greater depth. Under normal circumstances it is not exposed during low-tide; yet it may happen that the uppermost *Laminariæ*, especially when small, become exposed during extreme low-water, but this must be considered exceptional. What especially characterizes this zone is the circumstance that the associations are always submerged. The associations are certainly few in number, but most of them have a remarkably wide horizontal distribution, and the vegetation, taken as a whole, is homogeneous. With the exception of illumination the conditions of life must be supposed to be stable; in any case, compared with the conditions of life in the littoral zone, they are unstable to a very slight degree. In the littoral zone the change of season is noticeable, but in the deep, under normal circumstances, these changes are very slight. The character of the vegetation is therefore nearly the same all the year round.

The *Laminariaceæ* vegetation, as previously mentioned, is dominant in this zone and stretches in a broad belt along the coasts. Beyond the *Laminaria*-belt another narrower belt occurs composed almost exclusively of *Rhodophyceæ*.

14. The Community of Laminariaceæ.

This community occurs especially on a rocky substratum, and extends over large areas of the sea-bed from about the limit of low-tide to a depth of about 30 metres. It forms a belt round the coasts, and varies in breadth according to the conditions of depth and the nature of the substratum. This belt is for the most part

continuous, although only as far as the substratum is favourable for its development. By reason of the nature of the substratum, both the upper and the lower boundaries often have an irregular course, and stragglers from the main body of the vegetation often occur. Those *Laminariaceæ* which occur in the low-lying tide-pools must be regarded as stragglers from the *Laminariaceæ*-community which exists below. In the same way there are stragglers which extend outwards into deep water, as some members of the community have been found at a depth of 40 metres. The community occurs both on exposed coasts and on those which are partly exposed, as well as on sheltered coasts. It is composed of perennial species with, as a rule, strongly developed organs of attachment, a stem-like stipe and, as a continuation of this, a lamina or leaf-like portion which is originally undivided, but in some of the species, is later divided by longitudinal slits into many lobes. The species are the largest of all the algal species in the northern seas; they grow both in pure associations and highly intermingled with one another. The community may be said to resemble a "forest" on the sea-bed; sometimes the "forest" is pure, sometimes mixed, and it has its undergrowth, its "stem" epiphytes and its "leaf" epiphytes.

The species which occur are *Saccorrhiza dermatodea, Laminaria*-species and *Alaria*-species. Like the *Fucaceæ*-community in the littoral zone, the *Laminariaceæ*-community is composed of a few species of very social growth, and, just as the *Fucaceæ*-community forms the greater part of the bulk of the vegetation in the littoral zone, so does the *Laminariaceæ*-community below the limit of low-tide. If the range of the associations differs in depth this will be mentioned when they are described.

The Associations of the Laminariaceæ Community occur in many places in fairly regular succession from the coast out towards the deep sea. Thus, often quite close to the coast, *Laminaria saccharina* or *Alaria esculenta* is found occurring in very great abundance in pure or mixed associations; beyond is found a belt of *Laminaria digitata*; and deepest of all *Laminaria hyperborea*. But the order is not always so regular, and at lesser depths it is frequently seen that the species occur socially on small areas of the substratum, sometimes one species being dominant and sometimes another. The species may also occur scattered amongst one another, especially at lower depths. There is a difference in the

character of the community in sheltered and in exposed places, which is evident from the description of the association given below. In sheltered places the calm-water character predominates; to this belong the *Saccorrhiza dermatodea*-association, the *Alaria Pylaii*-association, the *Laminaria færöensis*-association and the calm-water associations of *L. saccharina* and *L. digitata*. Of the very much exposed associations, the only essential one to be recorded is the *Stenophylla*-association (see under *L. digitata*). In addition, a difference is evident according to the depth, and the associations then occur either with a shallow-water character or with a deep-water character (see below).

In its main features, this community occurs in a similar manner on the coasts of adjacent countries. The communities of S. and SW. Iceland greatly resemble those of the Færöes, as has been frequently mentioned, and also those of western Norway (Boye, 10; Hansteen, 25) and of Finmark (Foslie, 18).

The Saccorrhiza dermatodea-association. I have most frequently found this species just below the limit of low-tide, where it is of medium size, and grows scattered. In water-filled depressions in the lowest part of the littoral zone which, although they lie above the limit of low-tide, belong from a biological point of view to the lower-lying area, the species is often very social and forms pure associations. I have found it growing very socially at a greater depth (22—28 metres) within Reyðarfjörður in E. Iceland off Hólmanes or thereabouts; the specimens which occurred there were of large size. When the various *Ectocarpaceæ* which may occur on old individuals are excepted, the plants are usually free from epiphytes. The association develops best in somewhat sheltered places.

The Alaria Pylaii-association. *Alaria Pylaii,* as mentioned below, often grows interspersed amongst *Alaria esculenta f. pinnata, Laminaria saccharina* and others, in somewhat exposed places; but its real habitat is in the interior of the fjords, where the water is calm. Here occur the typical, large, broad-fronded individuals: they are often social in growth and then form pure or almost pure associations; but they are most frequently distributed in patches, and then alternate with *Saccorrhizeta* or social growths of *Laminaria nigripes v. atrofulva.* In such places occur also the broad-fronded calm-water forms of *Laminaria saccharina* and *L. digitata. Alaria*

Pylaii occurs thus as a calm-water form corresponding with the deep-water form of *Alaria esculenta* and with the form found on exposed coasts. I have found the *Alaria Pylaii*-association well developed in E. Iceland at a depth of 20 metres. The species also extends higher up and may, like all the other *Laminariaceæ,* occur at about the limit of low-tide or in the water-filled depressions in the lower littoral zone, but is then, like those *Laminariaceæ,* of small growth.

The Laminaria færöensis-association. The species in question grows socially at a depth of 20—30 metres in Fossárvík at the head of Berufjörður in E. Iceland. In its external appearance this association exactly resembles the deep-water association of *Laminaria saccharina.* The structure of the stipe differs however, because *L. færöensis* has a hollow stipe like *L. longicruris;* as Rosenvinge (63, p. 211) and Börgesen (12, p. 766) point out, the air-filled hollow space probably serves to lift the large lamina from the sea-bottom.

In deeper water, *L. færöensis* occurs in the same manner in the Færöes as it does in E. Iceland (Börgesen, loc. cit., p. 766), but differs somewhat in shallow water. In Greenland and Iceland, as in the Færöes, the hollow-stemmed *Laminariæ* prefer protected localities.

The Alaria esculenta-association. This is distributed very commonly along all the coasts of Iceland. It prefers a rocky substratum, but may occur also on pebbles as *Laminaria saccharina* occurs, and frequently in company with it. As a rule, the association is best developed at a depth of 6—16 metres; but the species occurs, in addition, growing socially at a depth of 3—4 metres and again, sometimes as deep as 30 metres. The association is pure or only slightly mixed, and then usually with *L. saccharina, L. digitata* or *Al. Pylaii;* it often stretches for miles in the fjords. The species *(Alaria esculenta)* varies in a manner somewhat similar to the variations of *Laminaria saccharina* and *L. digitata.* In very exposed places, there is found in shallow water a narrower-fronded form with narrow, leathery sporophylls. This form cannot be termed a surf-form like *L. digitata f. stenophylla* but it may, however, merit the title of an exposure-form. Another form, which is much larger, both as regards the length and breadth of its fronds, occurs in deeper water

(f. pinnata). This alga is one of the largest found on the coasts of Iceland, and may at times attain a length of 6—8 metres. The form of the frond resembles to some extent the shallow-water form of *Laminaria saccharina*, the thick mid-rib of *Alaria* corresponding with the thickened median area of *Laminaria*. The fronds of both species are thus well adapted to withstand the motion of the waves; in fact both species are rather frequently found intermingled in a broad belt along the coasts. On many of the sunken skerries which are such a danger in navigation, *Alaria esculenta* is the principal species, indeed frequently growing alone. In Hvammsfjörður in SW. Iceland, in places where a strong current exists (Röstin) there was found a dense vegetation of broad-fronded *Alaria esculenta f. pinnata* with very long laminæ.

It is general knowledge that the lamina is torn in pieces by the waves, and cases are frequent also in which the thin part of the lamina is divided into many pieces by transverse slits, often nothing remaining save the mid-rib itself, especially in the upper part of the lamina. A luxuriant *Alarietum* was found below the limit of low-tide at the extreme point between Seyðisfjörður and Loðmundarfjörður; it consisted mainly of *Alaria esculenta f. pinnata* with *Alaria Pylaii* and *Lam. saccharina* intermingled. It was at once noticeable that the uppermost *Alariæ* were entirely frondless; the stipes were completely overgrown with *Ectocarpaceæ*. It must be admitted that the situation was exposed, and therefore it may well be that the laminæ were destroyed by the beat of the waves; but there is just as much reason to believe that this was occasioned by the drift-ice, which had made its appearance on the coasts some time before my arrival. In this locality the *Fucus*-belt had also been scraped off the rocks in several places which, in my opinion, was caused by the drift-ice.

The Laminaria saccharina-association. This association is very luxuriant, and occurs almost pure over stretches extending for miles along the coasts. It does not always grow on a firm, rocky substratum: rather frequently it occurs on a pebbly substratum, in which case the plants are attached either to a single pebble or to several, as if lying at anchor. With dredgings, therefore, it rather frequently happens also that the plants with their "anchors" are dragged up from the sea-bottom. This association is met with from a depth of about 2 metres, or from

about the limit of low-tide, down to a depth of about 30 metres. Small individuals may be found in the lowermost water-filled depressions of the littoral zone. Compared with the other commonly distributed *Laminaria*-species, *L. digitata* and *L. hyperborea,* then *L. saccharina* generally keeps nearest to the coast, especially the more leathery, shallow-water form. In shallow depths the succession can be perceived distinctly, but with regard to greater depths conclusions must be drawn from what is brought up by the dredge. The succession usually is, that while *L. saccharina* keeps nearest to the land *L. hyperborea* extends deepest.

As is well known the species varies very much, according to the depth and the degree of exposure. A form with leathery, thick fronds with a rough surface occurs near land on somewhat exposed coasts in those depths where the effect of the beat of the waves is distinctly observable. At greater depths another form occurs, the deep-water form, with long, broad and comparatively thin fronds; and in protected localities inside the fjords of E. and W. Iceland a third form occurs at a depth of 4—20 metres. This form *(f. latifolia)* is long-stemmed, with comparatively very broad lamina and an entirely smooth surface. As each of these forms grows very socially the character of the association varies in accordance with the depth and the exposure.

The Laminaria digitata-association. This association is very common everywhere along the coasts where there is a rocky substratum, from a depth of about 4 to about 25 metres. On rocky coasts, however, small specimens occur just at the limit of low-tide, and there represent a kind of boundary. Small individuals may occur also in water-filled depressions in the lowest part of the littoral zone.

The tendency of *Laminaria digitata* is to vary in the same manner as *L. saccharina,* and thus the character of the association differs according to the depth and the degree of exposure, as the forms, individually, grow socially. The typical appearance of the association is determined by the deep-water form, or the typical form, which seems to grow most luxuriantly at a depth of about 10—20 metres. Here the species attains its greatest length and, as a rule, the stipe is so strong that it is able to raise the much-divided lamina from the bottom.

Just as the forms are connected with one another by inter-

mediate forms, so are the various associations connected. If the deep-water character of the association is taken as a starting point, we notice that it changes gradually with decreasing depths on exposed coasts, and that somewhere near the limit of low-tide it assumes an entirely different character, which is displayed in the leathery, long-stemmed form with a narrow and slightly-divided frond *(f. stenophylla)*. On an exposed coast this variety might be termed the shallow-water type or perhaps, rather, the surf-type, in conformity with the surf-form of *Fucus inflatus*. The surf-character was very beautifully and typically developed in the Vestmannaeyjar; here *f. stenophylla* grew very socially, forming a continuous belt, the upper boundary of which occurred almost at the limit of low-tide. When during low-tide the waves receded it was very interesting to see how easily the leathery, narrow, slightly-divided laminæ moved with the waves, and everywhere, as far as the waves receded, the rocky substratum between the *Stenophylla*-individuals was quite reddish in colour from the encrusting *Phymatolithon polymorphum*. The *Laminaria* plants were very firmly attached to the rock — a fact evidently well known to the fishermen, as they fastened the boat to a *Laminaria* while we went ashore. The stipe is leathery and pliable, and the plants cling closely to the substratum when the waves recede.

I have found *f. stenophylla* in other places, although not in such abundance, and not quite so typical. Here the same rule applies as with regard to *Fucus inflatus* and *Laminaria saccharina*, that the tendency to vary seems to depend on the greater or lesser movement of the water; on coasts which are somewhat exposed, a *Laminaria digitata*-association is rather frequently found at about the limit of low-tide, with a character midway between the surf-character and the deep-water character.

If we again take the deep-water character of the association as a starting point, and move inwards towards the protected coasts, we see that the character changes again, but in another direction. The stipe becomes shorter and the frond much broader and slit into fewer and broader lobes. Within the fjords, in W. and E. Iceland especially, the character is entirely different from the deep-water character. Here occur forms with very broad fronds which are either undivided or divided into two, or a few, very broad lobes *(f. cucullata)*. Generally the depth is about 4—20 metres, even deeper occasionally. I have found associations with this character

well developed in E. Iceland. At an insignificant depth, where I was able to see the sea-bottom, the individuals were not really closely placed, but lay on the bottom, some quite flat, and others slightly obliquely with the hollow surface turned upwards to the light. In this way the sea-bottom was almost entirely covered by the broad fronds.

This character might be termed the calm-water character, and an association-character exactly corresponding with it is found in *Laminaria saccharina* and *Fucus inflatus.*

Laminaria digitata f. cucullata occurs also scattered among *Laminaria nigripes v. atrofulva* and *Alaria Pylaii.*

The Laminaria hyperborea-association. It is developed luxuriantly in S. and SW. Iceland, and occurs also in E. Iceland and N. Iceland, in those places which I have visited. I can pronounce no opinion upon its general distribution in N. Iceland, as dredgings have been undertaken there in a few places only; yet I think that it occurs everywhere there. In E. Iceland, on the other hand, where I have done a great deal of dredging, I have only found it at the mouth of Berufjörður. It is very luxuriant in the Vestmannaeyjar, forming a continuous belt round the inhabited island.

The association grows on a rocky substratum, from a depth of about 4 metres to about 30 (or 40) metres, and occurs both on exposed and on slightly exposed coasts; close to the limit of low-tide and in water-filled depressions in the lowermost part of the littoral zone small specimens may occur. In shallow water, with exceptional low-tides, the upper part of the stipe is frequently seen rising above the surface, raising the lower part of the frond obliquely above the water. Börgesen (12, p. 755, Fig. 160) has reported and illustrated this from the Færöes.

In Iceland *L. hyperborea* does not vary in the same manner as do *L. saccharina* and *L. digitata,* the fact being that it does not occur in protected places, and on exposed coasts does not extend so far up as the two species mentioned. Those specimens which occur close to the limit of low-tide, or in pools in the littoral zone, are quite as typical as the large, deep-water individuals. The association seems to thrive best at a depth of about 20 to 30 metres, but on somewhat exposed coasts it also thrives fairly well at lesser depths, and is then very frequently mixed with the other members of the community; while at greater depths it is generally pure. As

is generally known, the species has very strong haptera, often arranged in rows, which issue from the lower part of the stipe, so that the haptera appear one above the other in vertical succession. They then look like a vertical row of obliquely placed props, one above the other; such rows issue in all directions from the stipe. By this it must be understood that, as the plant grows, new haptera appear, usually in the regular succession mentioned, until such time as the plant attains its normal size. The development of the haptera must necessarily keep pace with the rest of the growth, because the larger the plant becomes so much the more is it moved by the waves, and so much the stronger must the props become if the plant is not to be torn up. The youngest props are the longest, and are situated at the extreme (upper) end of the row. That the growth of the organs of attachment is contemporaneous with the increase in size of the individual applies also, of course, to the other *Laminariaceæ*, but scarcely anywhere is it seen so distinctly as in this species.

In its main features *L. hyperborea* behaves in Iceland — at any rate in S. and SW. Iceland — in the same manner as it is recorded by Börgesen (12, p. 755) to behave in the Færöes.

The Under-vegetation. No doubt an abundant under-vegetation occurs everywhere, chiefly formed of crustaceous algæ as a lower layer, and of branching or membranaceous *Rhodophyceæ* and a few *Phæophyceæ* in addition as an upper layer. Here, as in the *Fucus*-belt, it must be assumed that the under-vegetation is of no real value to the upper; while, on the other hand, the latter affords protection to the under-vegetation — in the *Fucus*-belt against desiccation and too strong light, and in the *Laminariaceæ*-community against strong movements of the water. The subdued light caused by the *Laminaria* fronds is, no doubt, also of importance in the upper portion of the *Laminaria*-belt, in so far, at any rate, that the species with a more downward range may endeavour to attain greater heights. In the lower portion of the *Laminaria*-belt the subdued light does not seem to affect the under-vegetation very much which seems to thrive there just as well as in open places where *Laminariaceæ* are absent; to have the waves moderated may be beneficial to the under-vegetation, especially in shallow water. During excessive ebb-tides opportunities may occur in many places of seeing how the *Laminaria* fronds moderate the motion of the waves, that is when this is not too violent, as, for example, when it approxi-

mates to surf. In deep water the *Laminaria* fronds will always moderate the motion.

In shallow water, especially where the bottom can be seen, it is easy to observe the under-vegetation, but in deep water one has to rely upon the specimens brought up by the dredge.

The under-vegetation is not divided according to the various associations of the upper vegetation, but seems to possess the same character wherever it is observed. In S. Iceland (the Vestmannaeyjar and Eyrarbakki) *Phymatolithon polymorphum* occurs in great abundance, covering the bottom entirely for large distances near the coast as an undergrowth. It is mainly composed of crustaceous, membranaceous, and more or less branching *Florideæ*.

A. Crustaceous Algæ. In several places in N. and E. Iceland I found a luxuriant under-vegetation formed of *Lithothamnion lævе, L. circumscriptum* and *L. glaciale*. Among these species the first mentioned especially seemed to be widely distributed both on the bottom of an *Alaria* and a *Laminaria* association. In E. Iceland *Lithothamnion flavescens* and *L. foecundum* in addition, like *Clathromorphum compactum*, were very frequent on a *Laminaria*-association-bottom. Together with these species occurred *Peyssonellia Rosenvingii, Cruoria arctica, Lithoderma* and others, as in the crustaceous algal vegetation (see p. 155).

B. Membranaceous and Branching filamentous species. The upper layer, with which are also associated intermingled species, varies considerably according to the depth. In addition to a number of the species which extend further downwards, various semi-littoral species may thus occur in the upper part of the *Laminaria*-belt. A number of the species which grow on the *Laminaria* stems may also occur on the bottom between the *Laminariæ*.

Here it is really a question of several associations; the lowest layer, as mentioned, is the crustaceous alga-association; the second layer is composed in its upper part of semi-littoral associations, which meet the associations which extend deeper and are mainly associations of *Rhodophyceæ*; and the uppermost layer is the *Laminaria*-association. The species are named where these associations are mentioned, and are therefore omitted here.

The Epiphyte-vegetation. Epiphytes very frequently occur on the stipes and laminæ of the *Laminariaceæ*, and it is a particularly common occurrence for old stems of *Laminaria hyperborea* to be entirely overgrown, for the epiphytic vegetation is much more

luxuriant on this species than on the remaining *Laminariaceæ*. It happens rather frequently, however, that a rich epiphytic vegetation occurs on *L. digitata, L. saccharina, Alaria esculenta* and *Saccorrhiza dermatodea*. The epiphytes generally occur most abundantly on the older individuals. The vegetation on the stems is usually composed of species which may be found growing among the *Laminariæ*, and then belong to the second layer of the under-vegetation, which can thus be raised upon the *Laminaria* stems; consequently, it is very natural that the composition of the species of the epiphytic vegetation should vary according to the depth. The following distinction is evident: that the semi-littoral species which grow epiphytically in shallow water vanish as the depth increases; while, on the other hand, some of the deep-water species may occur at a relatively lesser depth.

The following species have been found to occur on stems of *Laminariaceæ*, and may almost all be found on *Laminaria hyperborea:* —

Ahnfeltia plicata.
Antithamnion floccosum.
A. Plumula v. boreale.
Ceramium rubrum.
Delesseria alata.
D. sanguinea.
D. sinuosa.
Dermatolithon macrocarpum.
Euthora cristata.
Gigartina mamillosa.
Lithophyllum Crouani.
Lithothamnion circumscriptum.
Lomentaria clavellosa.
L. rosea.
Odonthalia dentata.
Petrocelis Hennedyi.
Peyssonellia Rosenvingii.
Plocamium coccineum.
Polysiphonia arctica.
P. parasitica.
P. urceolata.
Porphyra miniata.
Ptilota pectinata.
P. plumosa.
Rhodochorton repens.
R. Rothii.
Rhododermis parasitica.
Rhodophyllis dichotoma.
Rhodymenia palmata.
Desmarestia aculeata.
D viridis.
Ectocarpus confervoides.
E. fasciculatus.
E. Hinksiæ.
E. penicilliformis.
E. siliculosus.
E. tomentosoides.
Isthmoplea sphærophora.
Laminaria digitata.
L. hyperborea.
Leptonema fasciculatum.
Litosiphon filiformis.
Sphacelaria olivacea.
S. radicans.
Monostroma fuscum.
M. Grevillei.
M. undulatum.
Ulothrix flacca.
Ulva Lactuca.
Ulvella fucicola.
Urospora Wormskioldii.
51 species in all.

In addition, the fungus *Dothidella Laminariæ* must be mentioned; it is a very common endophyte in the stipe of various

Laminariaceæ. It occurs most commonly at depths of from 6—20 metres, but has also been found as deep as 30 metres.

Many of these species grow very socially and often cover the stipes completely, or nearly so. At Reykjavík, it is very usual in the spring to find *Laminaria hyperborea* in shallow water (4—10 metres) with the stipes entirely overgrown by *Rhodochorton Rothii, Antithamnion floccosum* and *Polysiphonia urceolata,* each on its own particular stipe, or else intermingled. *Petrocelis* and *Rhododermis* occur also in great abundance, almost covering entire stipes. In the Vestmannaeyjar and at Eyrarbakki it was also a fairly common occurrence to find stipes of *Laminaria hyperborea* completely overgrown by *Dermatolithon macrocarpum.* In the northern part of the country *Lithophyllum Crouani* also sometimes covers the stipe of *L. hyperborea* over its entire length. Many of the remaining species may also occur abundantly, but most frequently the vegetation upon the stipes is mixed, and crustaceous species grow side by side with branching and membranaceous species.

The epiphytic vegetation seems to be most luxuriant and richest in species at lesser depths, where the semi-littoral associations meet the associations which extend deeper down, and where, in addition to the *Rhodophyceæ* which always predominate, both brown and green species occur. At a greater depth the species are few, and are almost exclusively *Rhodophyceæ*. Generally, the rule seems to hold good that while the species with a more downward range occur on the haptera or on the lower part of the stipe, the more light-loving species occur on the upper part of the stipe; the green algæ, however, are by no means always uppermost. Thus in the upper portion of the *Laminaria*-belt *Euthora, Rhodophyllis, Odonthalia* and others frequently occur among the haptera, but in the lower portion of the belt they may be found on the stipe almost everywhere, especially *Euthora.* This agrees with Berthold's observation of the succession of epiphytes on *Cystosira* in the Mediterranean, and with Börgesen's observation of the order of the epiphytes on *Laminaria hyperborea* in the Færöes.

The vegetation on the stipe of *L. hyperborea* is extremely luxuriant in S. and SW. Iceland and is considerable both in NW. and N. Iceland, but is poor in E. Iceland.

Epiphytes frequently occur also on the fronds of the *Laminariaceæ,* especially in the upper portion of the *Laminaria*-belt. Here the brown algæ predominate, while only a few red and green

algæ occur. The following species are common or, at least, occur very socially: —

Chantransia Alariæ.
Rhodochorton membranaceum.
R. penicilliformis.
Ascocyclus islandicus.
Ectocarpus tomentosoides.
Litosiphon filiformis.
Myrionema Corunnæ.
Phæostroma pustulosum.
Pylaiella litoralis.
Streblonema Stilophoræ.
Acrosiphonia incurva.
Ulothrix flacca.

All the remaining *Ectocarpus*-species which are found on the stipes occur in addition. Of the species mentioned there are three in particular which grow very socially: *Chantransia Alariæ* covers the entire frond of *Alaria esculenta* from tip to base; *Ectocarpus tomentosoides* also grows very socially on the fronds of *Laminaria hyperborea* and *L. digitata* which it frequently, entirely or nearly, covers during spring-time, at which time, also, *Litosiphon filiformis* often covers large portions of the lamina of *L. saccharina*.

Myrionema Laminariæ and *Streblonema æcidioides*, in addition, grow as endophytes in the *Laminaria* fronds.

Thus, at least 62 species of marine algæ, or about 59 % of the algal species (113) which grow below the limit of low-tide, occur on or in *Laminariaceæ*.

On other coasts, those of the Færöes, for example (Börgesen, 11 and 12), and those of Norway (Boye, 10) a similar epiphytic vegetation occurs in the *Laminaria*-association. On the coasts of Greenland (Rosenvinge, 63) the epiphytic vegetation is much scarcer in the *Laminaria*-belt, which is possibly due, in part, to the absence of *Laminaria hyperborea* from that country.

15. The Desmarestia-association.

Desmarestia aculeata is very common and grows both scattered and socially; vertically it is widely distributed, as it has been found at depths of from 4—60 metres (in E. Iceland). It seems to grow most luxuriantly at a depth of about 6—30 metres, and then is frequently found in associations of lesser extent. Only rarely is this association found dominant on the bottom, and even then only in small patches. Most frequently it occurs intermingled with other associations; thus, when dredging on a *Laminaria* bottom, it very frequently happens that *Desmarestia aculeata* is brought up, and as frequently as not it is intermingled with the associations which extend deeper down. It often grows among the *Laminariæ*,

where there are openings in the *Laminaria*-vegetation, and beyond the *Laminaria*-belt it is very frequently found on a sandy or pebbly substratum, at any rate at inconsiderable depths. In the *Laminaria*-belt proper it plays the rôle of a kind of "underwood," but beyond the belt, at greater depths, it protrudes far above the associations of red algæ.

Desmarestia viridis occurs in a similar manner, very often with the other species, both inside and outside the *Laminaria*-belt. It is of less importance, however, as it is much less common. At depths of between 20—30 metres it may also occur dominantly in patches.

In E. Iceland, at a depth of 20—30 metres, *Chorda tomentosa* occurs growing very socially with the *Desmarestia* species.

Of the epiphytes on *Desmarestia aculeata* the small *Porphyropsis coccinea* is of most importance (in S. and SW. Iceland).

In several respects this association recalls the semi-littoral *Chorda*-association.

Similar *Desmarestia*-vegetation occurs in the Færöes (Börgesen, 14), in Greenland (Rosenvinge, 63) and in northern Norway (Foslie, 18, p. 100).

16. The Deep-water Community of Florideæ.

A mixed society, which consists mainly of a few species of red algæ, generally occurs at a depth of about 15—40 metres (over 50 metres in E. Iceland). To judge from the dredgings, the plants sometimes seem to grow socially — at any rate over small areas — and sometimes to grow scattered, then, as a rule, much intermingled with one another.

The species which seem to have an abundant local distribution in fairly many places are the following: *Delesseria sinuosa* at depths of from 14 to nearly 40 metres and somewhat deeper in E. Iceland; *Ptilota plumosa* from 16 metres to about 40 metres; *Odonthalia dentata* from 15—30 metres, and *Polysiphonia arctica* from 16—40 metres (10 to about 60 metres in E. Iceland). Thus each of these species forms associations, but these are often of inferior extent, with the exception, however, of that formed by the last mentioned species.

The Polysiphonia arctica-association. *Polysiphonia arctica* is of extremely social growth in E. Iceland, in Seyðisfjörður and in Reyðarfjörður. It grows most luxuriantly at depths of from 16—40 metres and forms an enormous, continuous belt along large

stretches of the coast. It is the only species of this community which forms a large, continuous and almost pure association, at any rate over considerable areas. The upper part of the association is, however, generally mixed with *Delesseria sinuosa, Ptilota, Odonthalia, Rhodophyllis* and others, and then these species often occur in such abundance that the community acquires its usual mixed character; that is, several species occur dominantly side by side, though no single species can be said to predominate.

Among the remaining species of the community *Rhodophyllis dichotoma* is often rather social. It is very common for *Euthora cristata* to occur intermingled, but to judge from the dredgings it seems to have a scattered growth. *Ptilota pectinata* may be of fairly social growth in E. Iceland. *Delesseria sanguinea* and *Polysiphonia urceolata* occur also in this community, the first mentioned appearing to be most frequent while, in a few places, the latter has been found in abundance.

Of the species with a scattered growth which belong to this community may be mentioned: *Lomentaria clavellosa* (20—40 metres), *L. rosea* (20—40) and *Plocamium coccineum* (20 metres), all in the Vestmannaeyjar; and also *Turnerella Pennyi* and *Omphalophyllum ulvaceum* in E. Iceland.

In many places the under-vegetation of the community is formed of crustaceous species of *Lithothamnion.*

Of the intermixed species, *Desmarestia aculeata* and *D. viridis* are very frequent. In E. Iceland *Chorda tomentosa* has been found intermingled in this community. In addition, *Laminariaceæ* of scattered growth such as *Laminaria hyperborea, L. digitata, L. saccharina, Alaria esculenta, f. pinnata* and *Alaria Pylaii* occur very frequently; they are the outposts of the *Laminariaceæ*-community.

It has been previously mentioned that many of the members of this community grow on *Laminaria* stems, and that in several places the community forms, together with species of *Desmarestia,* the second layer of the under-vegetation of the community of *Laminariaceæ.*

The community grows both on somewhat exposed and also on exposed coasts, and occurs both on a rocky and on a pebbly substratum, and even on sand.

The semi-littoral *Polysiphonia urceolata*-association has much in common with this community.

Rosenvinge (63) and, following him, Börgesen (12) call this

community or quite similar communities: the sublittoral *Florideæ*-formation.

17. The Lithothamnion-association.

In this association I include only the highly branched species, *Lithothamnion Ungeri* and *L. tophiforme*, as these differ from the other calcareous algal vegetations by their characteristic and very social growth. Within the fjords, at a depth of about 12—25 metres, these algæ occur in such abundance that there might be good reasons for calling it a submarine reef of calcareous algæ. Within Arnarfjörður in the vicinity of Bildudalur there was, for instance, such a luxuriant vegetation of *L. Ungeri* that the dredging-bag was filled time after time, nothing being found in it save this species. Mr. B. Sæmundsson has also found a similar *Lithothamnion* vegetation in several of the small fjords at Isafjarðardjúp; and as, moreover, there are specimens to hand from several other fjords in NW. Iceland, this association seems to be luxuriantly and commonly distributed in this part of the country. A similar vegetation, mainly composed of *L. tophiforme*, occurred also in abundance in Eyjafjörður in N. Iceland. I have also noticed a similar vegetation — though not so luxuriant — in several of the fjords of E. Iceland. Hörring collected *L. tophiforme* in Hvalfjörður in SW. Iceland, and Sæmundsson also found it there, apparently growing very socially.

In this association very few epiphytes occur, though *Turnerella Pennyi* ought to be mentioned in N. and E. Iceland; on the other hand animals generally occur in abundance, especially *Ophiurida* and snails and other smaller molluscs which project everywhere from between the *Lithothamnion*-branches.

When dredging on such a bottom rather large pieces are hauled up, which cohere, usually, by reason of the numerous branches being matted together. Rather large globular masses, which are sometimes hollow, but which are often filled with comparatively thick interwoven branches, are also frequently obtained. The hollow masses must be supposed to have grown on the outer side of some substratum which has disappeared. This *Ægagropila*-form is generally known. Rosenvinge mentions it from Greenland, and assumes that it lies loose upon the bottom; the masses must then be illuminated all round by being rolled about as, for instance, by the action of the undercurrent. From what I have seen, it seems to me that a point of attachment can be perceived on entirely fresh

forms of *Ægagropila,* and in my opinion they are outgrowths upon old "blocks" of calcareous algæ. The action of the current probably loosens them, and they then roll about on the bottom. Undoubtedly they can live fairly long in that condition, but if they roll about much, they will surely by degrees go to pieces.

This association recalls the semi-littoral *Corallina*-community, particularly the *Corallina*-association.

The *Lithothamnion*-association occurs in Greenland (Rosenvinge, 63) but not at the Færöes (Börgesen, 12).

18. The Community of Crustaceous Algæ.

The characteristic life-form of the crustaceous algæ which is so essentially different from that of the rest of the marine algæ seems to justify the idea that they all belong to one community. With all of them the thallus is flat and, like the crustaceous lichens on the rocks, adheres by the whole of its lower surface to the substratum. As the form and the manner of development of the thallus in the different species are identical in their main features, I think that the community may appropriately be named after the crustaceous growth.

The substratum of the community consists of rocks, pebbles, mussel-shells and the like; also of other algæ, especially species of *Laminaria.*

The community has a very large distribution both in a horizontal and in a vertical direction, and possibly it is more particularly members of this community which we may expect to find in the vicinity of the absolute depth-limit of growth of algal vegetation. The community has already been mentioned as the undervegetation in the *Laminariaceæ*-community; it occurs also as an undergrowth in communities which extend to a greater depth and thus, partly as a dominant growth on the bottom and partly as undergrowth, it reaches from the great depths right up to the limit of low-tide. The semi-littoral and the littoral crustaceous alga-associations should also be regarded as part of this community although, for practical reasons, they have been dealt with earlier in this paper. The community is pure, that is to say it is composed of only crustaceous algæ; there occur, it is true, various intermingled species, of which the majority are *Florideæ,* though some are *Phæophyceæ,* but these I consider unessential and almost irrelevant to the crustaceous alga-community proper. They have their homes in other communities,

and sometimes, perhaps, are in the act of forming an upper vegetation; sometimes they may be individuals which have "strayed" beyond the real limits of their community.

The community is divided into various associations, according as to whether the one or the other of the species is dominant over considerable areas. A widely distributed and typical Phymatolithon-polymorphum-association occurs, thus, in S. Iceland, and *Lithothamnion Lenormandi* has a fairly social growth at Reykjavík. *L. lœve* and *Clathromorphum compactum* also form associations in several places. Judging from the dredgings, *Lithothamnion flavescens* and *L. foecundum* have a more scattered growth while, on the other hand, *L. glaciale* often occurs abundantly. Otherwise, it is very common for the *Lithothamnion* species to grow intermingled with, and at times upon, one another. The crustaceous, calcareous algæ form the greater part of this community in Iceland. The remaining crustaceous species, such as *Peyssonellia, Cruoria arctica* and *Lithoderma fatiscens,* are found more scattered, although the last-named species forms associations in shallow water right up to the limit of low-tide. These species must, however, be much more common on the sea-bottom than is shown by the dredgings. It may be taken for granted, also, that *Petrocelis Hennedyi* and *Rhododermis parasitica* occur on a stony substratum in deeper water, seeing that they are so common on the stems of *Laminaria hyperborea* at considerable depths. Both *Hildenbrandia* and *Petrocelis* occur on a stony substratum at shallower depths, and also *Ralfsia ovata.*

The species which has, with absolute certainty, been found growing deepest is *Lithothamnion lœve* (see Part V), and it occurs in masses at a depth of 88 metres, that is, it forms a *Lithothamnionetum* at this depth. Thus, of all the marine algal communities in Iceland, this community extends deepest.

A similar vegetation occurs in Greenland (Rosenvinge, 63, p. 223), and in other places in the Arctic Sea (Kjellman, 36), but in both these places it differs in the wider distribution and greater luxuriancy of the *Lithoderma fatiscens*-association. In the Færöes (Börgesen, 12) the conditions seem to be somewhat similar, similar in any case to the conditions in S. and SW. Iceland, although *Lithoderma fatiscens* seems to occur there more sparsely than in Iceland.

B. The Sea-grass Vegetation.

The Zostera-association.

This association differs so much from the other marine communities in Iceland — the marine algal communities — that it must be regarded as not being in any way connected with them. The present community occurs especially on a substratum of muddy clay, which the algæ avoid. The "roots" of the algæ — the haptera — are organs of attachment only, their sole function being, in most cases, to attach the plant to the substratum — the stony substratum —, while *Zostera* has true roots which obtain nourishment from the substratum. For this reason *Zostera* requires a good nutrient substratum which is generally soft. It is rare, indeed it must be reckoned exceptional, for *Zostera* to be found growing on a hard clay-substratum. I understand such cases to indicate that formerly the substratum had been softer and then became more compact owing to the deposition of clay and sand, and that the *Zostera* is consequently about to disappear from such a spot. In places where there is no danger of either sand or clay being deposited from brooks or rivers the substratum will, nevertheless, scarcely remain unchanged, as the mud and ooze which are thrown down everywhere in the ocean, when once they have been brought to a place, readily accumulate and remain, in the shelter of the dense vegetation.

The *Zostera*-vegetation occurs widely distributed, especially in SW. Iceland where, in many places, both inside the smaller arms of the fjords and in the large fjords such as Breiðifjörður, a substratum of muddy clay occurs between the coast and the skerries which lie nearest. At Breiðifjörður, during low-tide, the pale-green *Zostera*-belt may be observed stretching for miles along the coast. At Faxaflói also the *Zostera*-vegetation has an extensive distribution. *Zostera* is found, most certainly, on other parts of the coast of Iceland, but nowhere have I seen such extensive "meadows" of it as in SW. Iceland.

The vegetation is generally pure and there is hardly an association of species in the sea off these coasts which is less mixed than the Zostera-association. In other places *Zostera* is a favourite substratum for epiphytes, but however much I searched I did not find anything worth mentioning on the *Zostera* plants here; in this respect the *Zostera*-meadow of Iceland agrees with that of the Færöes. At times, species belonging to the semi-littoral commu-

nities occur intermingled in the *Zostera*-belt; these then grow in small depressions, where the subsoil, usually a solid, clayey and pebbly substratum, appears. Such species are: *Chorda Filum, Chordaria flagelliformis, Castagnea virescens, Dictyosiphon foeniculaceus, Pylaiella littoralis, Ceramium rubrum, Cystoclonium purpurascens* and others. They should not be classed in the *Zostera*-association, and are mentioned only to explain the appearance of the *Zostera*-meadow.

The *Zostera*-association is sublittoral, but hardly extends as far down as do the semi-littoral communities. It cannot endure protracted exposure, and thus a substratum which would adapt itself well to *Zostera* may be found completely devoid of plants in places which are exposed for a long time during low-tide. From time to time, during extreme ebb-tides, the upper part of the *Zostera*-meadow may, however, be seen quite dry. But here two points have to be taken into consideration: the first being that the period of exposure is extremely short, and the second being that the extreme ebb-tides occur so seldom that they ought not to be taken into calculation. As a rule, the *Zostera* substratum is always submerged during low-tide. The water is so low, however, that the leaves float on the surface of the water, giving it a greenish tinge. When wading in a *Zostera*-meadow during low-tide the water reaches to about the knees.

In SW. Iceland the time of fruiting is during August—October.

On *Zostera*-soil there is in most places a very rich animal-life, but whether this has any influence upon the vegetation or on the nutrient substratum needs further investigation.

In connection with the *Zostera*-association I will just mention the Brackish-water-vegetation. It is so little known that there is nothing to be said about it, except that I have found *Ruppia maritima* in one solitary spot, where it grew so luxuriantly that, although scattered, it characterized the bottom.

VII. DIFFERENCES IN THE VEGETATION IN EAST AND SOUTH ICELAND.

East Iceland and South Iceland — at the south-eastern corner of the island, at about the stretch of coast from Vestrahorn to Eystrahorn — are divided by a rather sharp boundary both as regards the hydrography and the composition of the vegetation, as has been mentioned above. On the other hand, E. Iceland is connected with S. Iceland by a large transitional area (see p. 67) which stretches further along the north and north-west coasts and a part of SW. Iceland. The difference as regards the vegetation is therefore greatest between E. Iceland and S. Iceland; so it is these coastal districts which will exclusively or almost exclusively be treated of in this part of the present paper.

Where a great floristic difference exists between the different parts of the coast as, for instance, between E. Iceland and S. Iceland[1] (see Part III) it is to be expected that there will be differences in the vegetation, more especially as some of the species which are not common to all the coastal districts grow socially and form associations. The majority of the communities and the associations are however common to all the districts and are somewhat similar in appearance, as is also seen from the above description (Part VI), where the differences are always mentioned.

As regards the communities and associations common to both districts it is enough to refer to the above description. Here, only those communities and associations will be mentioned which are found in the one district but are absent from the other.

[1] The greater part of the coast of S. Iceland is a sandy coast or a barren "desert;" in this part of the present paper, by S. Iceland is meant only that part of the coast where vegetation occurs — the Vestmannaeyjar and the stretch of coast from Reykjanes in the direction of Thjorsa or somewhat more to the east than Stokkseyri.

Occurring in E. Iceland and absent from S. Iceland.	Occurring in S. Iceland and absent from E. Iceland.
Arctic Associations.	Boreal Communities and Associations.
The *Monostroma groenlandicum*-association.	The *Pelvetia-Fucus-spiralis*-belt.
The *Polysiphonia arctica*-association.	The Community of *Corallina*.
Subarctic Association.	The *Fucus serratus*-association.
The *Laminaria færöensis*-association.	The *Phymatolithon-polymorphum*-association.

Further it should be pointed out that the epiphytic vegetation on *Laminaria hyperborea* is quite infinitesimal in E. Iceland, but very luxuriant in S. Iceland.

Of E. Iceland species which are important to the vegetation, *Laminaria nigripes*, *Turnerella Pennyi* and others are absent from S. Iceland. Of S. Iceland species which play a prominent part in the vegetation a great many are wanting in E. Iceland (see Part III).

The Zostera-association requires to be described separately. It belongs properly to SW. Iceland. *Zostera* is also known to occur in E. Iceland and it is possible that it forms associations there, but they are probably far more limited in extent than those in SW. Iceland. *Zostera* has not been found in S. Iceland itself, which is probably due to the fact that a favourable substratum for it is wanting there.

If we now leave the *Zostera*-association out of consideration, as the latter does not occur in S. Iceland, and confine our attention to the above-mentioned communities and associations which are found in the one district but are absent from the other, then it is seen that at any rate some of them characterize the vegetation to a considerable extent.

The Monostroma groenlandicum-association, as already mentioned, is peculiar to E. Iceland and has a considerable extension in several places there. It is not found in S. Iceland. *Monostroma groenlandicum* occurs sparingly both in N. Iceland and NW. Iceland, therefore it is possible that this association is not exclusively confined to E. Iceland. As the community of filiform algæ is commonly distributed both in E. and S. Iceland and green filiform algæ occur very luxuriantly in S. Iceland, the absence of *M. groenlandicum* from the latter place is of no essential importance to the vegetation as regards appearance.

The Polysiphonia arctica-association is of importance as regards the appearance of the sublittoral vegetation in E. Iceland. This association does not occur in S. Iceland, but a corresponding one occurs, which is however far less luxuriant, composed of *Polysiphonia urceolata.*

The Laminaria færöensis-association is known to occur only in E. Iceland. This association is probably more widely distributed along Iceland than is at present known; the species occurs at any rate in N. Iceland. But I think that this species will hardly be found along the coast of S. Iceland owing to the fact that sheltered localities are wanting there.

The Pelvetia-Fucus-spiralis-belt is most commonly distributed in S. and SW. Iceland, and composes there the upper part of the *Fucaceæ*-community. As this belt is absent from E. Iceland there is a considerable difference in the appearance of the uppermost part of the *Fucaceæ*-community in the coastal districts in question. *Fucus spiralis* is, however, found in E. Iceland.

The Community of Corallina is also peculiar to S. and SW. Iceland and absent from E. Iceland. This community, or the *Corallina-Gigartina* belt, is very luxuriant and often of considerable extent in S. Iceland (and SW. Iceland), owing to which the semilittoral vegetation in E. Iceland and in S. Iceland differs highly in character.

The Fucus serratus-association is poorly represented in S. Iceland, but it is luxuriant in a single locality in SW. Iceland. As *Fucus serratus* is rare, and somewhat resembles in appearance the large, broad-leaved forms of *Fucus inflatus* which are common everywhere, it plays only an inconsiderable part as regards the appearance of the *Fucaceæ*-community.

The Phymatolithon polymorphum-association is peculiar to S. Iceland, but as other crustaceous, calcareous algæ occur in E. Iceland in a similar manner though less luxuriantly, the absence of *Phymatolithon polymorphum* is of no essential importance as regards the appearance of the crustaceous-alga-vegetation.

From what has been stated above it is evident that the occurrence of the *Pelvetia-Fucus-spiralis*-belt and the *Corallina-Gigartina*-belt in S. Iceland (and SW. Iceland) gives to the littoral and semilittoral vegetation of the southern district a character different from that of E. Iceland.

If we now turn to the individual species which (besides those already mentioned) are found in the one coastal district but are absent from the other, and which are important as regards the appearance of the vegetation, we see, as already mentioned, that such species are few in E. Iceland and numerous in S. Iceland. Some of these species have a fairly social growth without, however, forming independent associations. In the following, only those species are given which occur most abundantly.

East Iceland.	South Iceland.
Lithothamnion flavescens.	Lomentaria clavellosa.
L. foecundum.	Plocamium coccineum.
Laminaria nigripes.	Chantransia Alariæ.
Turnerella Pennyi.	Callithamnion Arbuscula.
Ptilota pectinata.	Plumaria elegans.
Peyssonellia Rosenvingii.	Ceramium acanthonotum.
Coilodesme bulligera.	C. rubrum.
Ulothrix consociata var. islandica.	Polysiphonia fastigiata.
	Rhododermis parasitica.
	Cystoclonium purpurascens.
	Ptilota plumosa.
	Petrocelis Hennedyi.
	Ectocarpus fasciculatus.
	E. tomentosus.
	Cladophora rupestris.
	Enteromorpha Linza.

It should moreover be noted that all the *Ceramium*-species are absent from E. Iceland. In S. Iceland, besides those mentioned above, *Ceramium atlanticum* occurs, and it will no doubt be possible to find several more *Ceramium*-species in S. Iceland.

The Epiphytic Vegetation on *Laminaria hyperborea*, as mentioned several times, is very luxuriant in S. and SW. Iceland; in NW. and N. Iceland it must also be said to be fairly luxuriant, but in E. Iceland it is quite infinitesimal in amount, which is probably connected with the fact that *Laminaria hyperborea* is rare in E. Iceland.

The epiphytic vegetation on the stipes of *Laminaria hyperborea* is very luxuriant and finely developed in S. Iceland. The following from the Vestmannaeyjar are given as an example: — dominantly on the stipe of *L. hyperborea* occurred *Rhodymenia palmata, Delesseria alata* and *Plocamium coccineum;* less abundantly than the three above-mentioned species occurred *Delesseria sanguinea, Lomentaria clavellosa, Lomentaria rosea, Euthora cristata, Gigartina mamillosa, Ahnfeltia plicata, Petrocelis Hennedyi, Dermatolithon macrocarpum* and

Pterosiphonia parasitica. To show how rich in species the epiphytic vegetation occurring on a single individual of *L. hyperborea* may be, the following species, also from the Vestmannaeyjar, may serve: *Desmarestia viridis, Ptilota plumosa, Delesseria sinuosa, Delesseria alata, Lomentaria clavellosa, Polysiphonia urceolata, Plocamium coccineum, Delesseria sanguinea* and *Euthora cristata.*

So luxuriant and finely developed an epiphytic vegetation gives to the *Laminariaceæ*-community of S. Iceland a character different from that which it has in E. Iceland.

On the stipes of *Alaria* and *Laminaria digitata,* on the other hand, a similar epiphytic vegetation occurs in both the coastal districts.

The zonal division of the marine algal vegetation is in its main features similar in E. Iceland and S. Iceland, as is shown by the following examples which have been taken straight from the diaries.

East Iceland.

Vattarnes, steep cliffs, highly exposed. $^{14}/_{7}$.

I. Ulothricetum U. flaccae.
II. Bangietum B. fuscopurpurae.
III. Porphyretum P. umbilicalis.
IV. Fucetum F. inflati, in the most exposed localities, consisting only of f. exposita.
V. Rhodymenietum.
Halosaccionetum.
Acrosiphonietum.
VI. Sublit. Alarietum.

Borgarnes, sloping rocky coast, considerably exposed. $^{13}/_{6}$.

I. Prasioletum P. stipitatae.
II. Ulothricetum U. flaccae, in great abundance.
Rhizoclonium in crevices.
III. Bangietum B. fuscopurpureae, in wonderful abundance.
IV. Porphyretum P. umbilicalis, of great extent.
V. Monostroma groenlandicum.
VI. Fucus vesiculosus, sparse and miserable.
VII. Fucetum F. inflati, abundantly. The specimens very variable.
VIII. Halosaccionetum H. ramentacei.
Urospora Wormskioldii.
Polysiphonia urceolata.
Rhodomela lycopodioides.
Chorda tomentosa.
IX. Alarietum.

Hólmanes, somewhat exposed, sloping rocky coast. $^{18}/_{7}$.

I. Ulothricetum U. flaccae.
II. Enteromorphetum E. intestinalis.
III. Fucetum, uppermost, narrow margin of F. vesiculosus, below that, broad belt of F. inflatus, intermixed here and there sparsely with Ascophyllum nodosum.
Under-veg. Hildenbrandietum.
IV. Halosaccionetum, intermingled with Monostroma fuscum, Porphyra miniata, Rhodymenia palmata and a few Fucus inflatus.
V. Alarietum, composed of Alaria esculenta and A. Pylaii.
VI. Laminarietum L. saccharinae.
VII. Laminarietum L. digitatae.

South Iceland.

Vestmannaeyjar, much exposed, steep, rocky coast. $^{20}/_{5}$.

I. Ulothricetum U. flaccae.
II. Porphyretum P. umbilicalis.
III. Ascophylletum A. nodosi.
IV. Gigartinetum G. mamillosae, broad belt, in it Corallina officinalis, Ceramium acanthonotum, Callithamnion, Delesseria alata.
V. Corallinetum C. officinalis, dispersed in it Laminariae.

Vestmannaeyjar, Víkin, considerably exposed, sloping rocky coast. $^{21}/_{5}$.

I. Ulothricetum U. flaccae.
Enteromorphetum E.* micrococcae.
Acrosiphonietum.
II. The Fucus-belt.
Ascophyllum nodosum.
F. vesiculosus.
F. inflatus.
III. Gigartinetum G. mamillosae } floating
IV. Corallinetum C. officinalis } together.
V. Laminarietum L.* stenophyllae.
VI. Alarietum A. esculentæ.
VII. Laminarietum L. hyperboreae.

Vestmannaeyjar, the skerry, considerably exposed, sloping rocky coast almost destitute of phanerogams. $^{18}/_{5}$.

Uppermost, Cochlearia officinalis and rosettes of Plantago maritima.
At the same level, in crevices:
I. Enteromorphetum E.* micrococcae, + Cladophora sericea.
II. Ulothricetum U. flaccae, Prasioletum P. stipitatae } on flat rocks between crevices.
III. Pelvetia canaliculata.
IV. Fucus spiralis.
V. Ascophylletum A. nodosi.
F. vesiculosus.
F. inflatus.
Under-veg. Callithamnionetum.
Antithamnion.
Gigartina.
VI. Gigartinetum G. mamillosae.
VII. Laminarietum L.* stenophyllae.
Under-veg. Phymatolithon polymorphum.

South Iceland, south side of Reykjanes, according to C. H. Ostenfeld's diary.

Staður, wide foreshore, considerably exposed. $^{12}/_{6}$.

1. Pelvetia canaliculata.
+ stunted F. vesiculosus.
2. Fucus spiralis, with stunted Ascophyllum and Cladophora rupestris.
3.a Ascophyllum + Polysiphonia fastigiata, broad belt.
3.b Fucus vesiculosus formation, in it F. inflatus, widely distributed,
3.c in it Gigartina.
4. Here and there in depressions the formations:
Monostroma Grevillei and M. fuscum.
+ Halosaccion.
Cystoclonium.
Ahnfeltia.
Dictyosiphon foeniculaceum.
Rhodymenia.
5. Laminaria + Alaria.

The foreshore between Staður and Reykjanes. $^{13}/_{6}$.

1. Uppermost, Porphyra umbilicalis.
F. spiralis.
F. vesiculosus f. sphærocarpa.
Enteromorpha compressa.
2. F. inflatus-formation, widely distributed and in it Gigartina.

3. Gigartina, widely distributed.
   Rhodymenia.
   Plumaria elegans.
   Delesseria alata.
   Acrosiphonia.
   Monostroma Grevillei.
   Chætomorpha Melagonium.
   Delesseria sanguinea and others.
4. Corallina widely distributed, in a single pool Halosaccion.
5. Laminaria + Alaria.

In another part:
Ascophyllum in quantities between 1 and 2.

It would carry us too far to give several more examples from the diaries, but on regarding the material taken as a whole it is distinctly seen that there is no other difference of importance between the two districts with regard to the zonal division of the algal vegetation beyond the fact that some of the communities and associations occur in one place and are absent from the other. The division of the belts varies somewhat in both places which is chiefly due to the greater or smaller degree of exposure of the locality (see Part VI).

The most conspicuous difference in the division of the belts in E. Iceland and S. Iceland is due to the enormous size of the *Corallina*-belt in the latter place. This community (*Gigartina, Corallina* and others; see Part VI) occurs just below the *Fucus*-belt where, for instance, in the Vestmannaeyjar it is the dominant one; this also applies to Eyrarbakki and the south side of Reykjanes, but perhaps to a somewhat less degree. This leaves less room for the *Rhodymenia*-community (*Rhodymenia, Halosaccion;* see Part VI), which also forms a belt below the *Fucus*-belt; consequently it is not so large there as in E. Iceland where it is extremely common and in several places widely extended. In many places in SW. Iceland the *Rhodymenia*-community is as large as in E. Iceland.

The sea off the coast of S. Iceland is in movement everywhere, and calm water is almost unknown. The calm-water-vegetation proper, which is so common within the fjords of E. Iceland, is therefore absent from S. Iceland, but is again found richly represented in SW., NW. and N. Iceland.

The luxuriancy of the vegetation is somewhat similar in both places; it appears, however, to be greater in the Vestmannaeyjar and the western part of the south coast.

Depth-limit. It appears that there is reason to believe (see Part V) that the algal vegetation extends to greater depths in the fjords of E. Iceland than on the south coast, but as this cannot be regarded as sufficiently proved I shall not enter into it more fully.

VIII. SOME NOTES ON THE BIOLOGY OF THE ALGÆ ALONG THE COAST OF ICELAND.

At present very little is known with regard to the biology of the marine algæ along the coast of Iceland. What is known, on the whole, regarding this point is for the most part mentioned in the "Marine Algæ of Iceland" (31) under each species. Some observations which have been made subsequently will be mentioned in the following pages. Of these, I regard those which have been made during winter as the most important, although they are very incomplete owing to the fact that during winter I have only rarely been able to make investigations, and then have had access to the littoral zone only; thus, with the exception of a few species, the winter-habit of the sublittoral species is not known. Consequently I can, by no means, treat of the biological conditions exhaustively, but must content myself with giving a few incomplete contributions.

On the whole, the behaviour of the species is best known in spring and summer, less well in autumn, and least well during winter. From most of the coastal districts there are observations to hand either only those of a single season of the year, or at most of two or three seasons. From Reykjavík we have observations of all four seasons, but those of the winter are sparse, and only a few species have been observed throughout the year.

The observations to hand are so few and insufficient that a comparison of the biological conditions in the five coastal districts in question cannot be made; here, therefore, Iceland is treated for the most part as an entirety.

1. Duration of Life.

The life-period of the algal species is of very varying length; in this connection the algæ may be divided into two groups: annual algæ and perennial algæ.

A. Annual algæ. The annual species are especially the Green Algæ which grow in the upper littoral zone and are exposed during each low-tide. The upper littoral zone is that part of the algal region where the change of seasons is most felt and where winter prevents many species from continuing life. Such species then produce spores which live through the winter as such, or in the early stages of germination. Of annual species the following may be mentioned: —

Codiolum gregarium.
C. pusillum.
Percursaria.
Enteromorpha-species.
Monostroma-species.
Prasiola-species.
Ulothrix-species.
Ulvella.
Pringsheimia.
Urospora-species.
Chætomorpha tortuosa.
Spongomorpha vernalis.
Cladophora-species.

In addition, some of the endophytic species must be regarded as belonging to the annuals, although some of them can be met with at all seasons of the year. As examples of such species may be mentioned: — *Chlorochytrium*-species and *Codiolum Petrocelidis*.

The life-periods of the species mentioned above are probably of different lengths and it is possible that some of them can produce several generations during one summer (cf. Börgesen, 11 and 12). The majority of these species grow luxuriantly during spring (March—May) and summer (June—August), produce spores at the end of summer and then die. Some of them, however, continue life into the autumn (September—November), or at any rate until September. A few may also be met with during winter (December—February), e. g. *Enteromorpha intestinalis f. prolifera*, *Monostroma fuscum* (sterile and fruiting), *Cladophora rupestris* (abundantly) and *Cladophora sericea* (sparingly).

Of the above-mentioned endophytic species I shall refer to *Chlorochytrium inclusum* and *Codiolum Petrocelidis* only. Both these species occur at all seasons of the year. They are found most frequently in the host-plants in the sublittoral zone, where the conditions of life must be considered to be more stable than in the littoral zone. I regard such species as short-lived. They are found all the year round, as probably several generations are produced during the year.

Among the annual Brown Algæ the following must be included: — *Myrionema*-species, *Ascocyclus* and the majority of the *Ectocarpaceæ*, *Leptonema*, *Litosiphon*, *Isthmoplea*, *Phæostroma*, *Ca-*

stagnea and *Leathesia* (living from June to September). In addition there are species which may be supposed to be annual, as for example, *Punctaria*, *Stictyosiphon*, *Scytosiphon* (?), *Phyllitis*, the majority of the *Dictyosiphonaceæ*, *Chorda*-species, etc.

Of Red Algæ the following must be presumed to be annual: — *Bangia*, *Porphyra*-species, *Porphyropsis*, *Conchocelis*, *Chantransia*-species, *Ceramium*-species and possibly several more. As regards *Porphyra umbilicalis* it should, however, be stated that it has been found at all seasons of the year and at Reykjavík it occurs as luxuriantly in December—January as during the spring.

B. Perennial Algæ. With regard to some of the species it is difficult to decide whether they are perennial or annual, as our knowledge of them is incomplete; consequently it is sometimes a matter of opinion whether they are to be included in the one or in the other group. Only a few of the Green Algæ are perennial, as for instance, the majority of the *Acrosiphonia*-species. The latter, besides being reproduced by spores, have also abundant vegetative reproduction by means of offshoots; and some of them, as for instance, *A. albescens* and others, live all the year round in the semi-littoral zone.

Of the Brown Algæ the *Fucaceæ* and the *Laminariaceæ* are perennial. It is, however, doubtful whether we are justified in including *Saccorrhiza dermatodea* among the perennials. At Reykjavík I have seen only old fruiting specimens in the winter, and judging from their appearance it is very probable that they die during the winter; nothing can, however, be stated with certainty regarding this point.

In the fjords of E. Iceland large individuals of this species were growing in the sublittoral zone; I believe they were more than one year old, but I could not prove this. In Greenland (Rosenvinge, 61, p. 852) perennial or upwards of a year old individuals of this species occur.

With regard to several other species of Brown Algæ it is not easy to say at present whether they are annual or perennial. I think, however, that the following may be classed as perennial: — *Lithoderma*, *Ralfsia*-species, *Sphacelaria*-species, *Chætopteris*, *Desmarestia aculeata*, *D. ligulata*, *Chordaria flagelliformis* (?).

I think that the majority of the Red Algæ are perennial or can, at any rate, live through more than one growth-period. I shall,

in the following, name some species which I am fairly certain may be included among the perennials: —

Gigartina mamillosa.
Ahnfeltia plicata.
Euthora cristata.
Rhodophyllis dichotoma.
Rhodymenia palmata (?).
Halosaccion ramentaceum.
Polysiphonia urceolata.
Rhodomela lycopodioides.
Odonthalia dentata.
Ptilota plumosa.
Rhodochorton Rothii.

The crustaceous algæ such as *Hildenbrandia*, *Petrocelis*, *Cruoria*, *Peyssonellia* and *Rhododermis*, and by far the greater number of the calcareous algæ must also be classed as perennial.

2. Periodical Changes.

The Period of Activity. The Period of Rest. The period of activity of the annual species is identical with their period of life and it extends, probably as regards the majority of the species, over the spring and summer months. The perennial species and the species which can live more than one year, have a very long period of activity which extends over the greater part of the year with the exception of the darkest part; consequently these species have a very short period of rest. Although from the observations to hand it is not possible to fix the length of the period of rest, yet they indicate that it must be short. The *Fucaceæ* may be mentioned as an example. Their vegetative growth appears to be very slight during December—January, and in the case of the older individuals there is probably none at all at that time; but although the majority of the individuals of the *Fucaceæ* are sterile during winter yet, even in December, reproductive organs are developing here and there. Young plants of the summer or autumn appear to have vegetative growth also during the winter. In the *Fucaceæ*-belt, taken as a whole, the period of rest is consequently extremely short. In the sublittoral zone I think that entire rest must be of extremely short duration.

Renewal of the lamina. The young shoots. As is well known, a renewal of the lamina takes place yearly in the *Laminaria*-species. At what time this takes place in Iceland cannot be stated with absolute certainty, but the observations seem to indicate that the new lamina begins to grow even in the winter time, as the light increases. I believe that in SW. Iceland a general renewal of the

lamina takes place in February—March. In April individuals with large, new laminæ, with the old laminæ or portions of them still attached, are frequently found at Reykjavík, but the majority of the *Laminaria* individuals have renewed their laminæ by that time. A few individuals are however met with until June in SW. Iceland in the act of lamina-renewal. With regard to some of the most common species the following may be noted: —

Laminaria saccharina in SW. Iceland (1897) was frequently found in the lamina-renewal stage in April, while some individuals were renewing their laminæ in May. *Laminaria digitata:* some individuals were renewing their laminæ in April and until June in SW. Iceland (1897). *Laminaria hyperborea* in SW. Iceland (1897), some were renewing their laminæ in May—June.

L. hyperborea was found renewing its laminæ in July on the north coast of Iceland. This was observed only once, therefore it cannot be concluded from this that the lamina-renewal stage commences later or lasts longer on the north coast than in SW. Iceland.

In the Færöes (Börgesen, 11 and 12) the lamina-renewal stage occurs at the same time as in SW. Iceland.

On the west coast of Sweden the renewal of the lamina takes place during winter (Kylin, 45) and in *Laminaria saccharina* and *L. digitata* the young leaf, in December, is a quarter the size of the old one; in April it is only exceptionally that individuals are found with a portion of the old lamina attached. The renewal of the lamina in *L. hyperborea* takes place later, and in April the new lamina is a quarter the size of the old one, and in the beginning of July a portion of the old lamina is still present.

In connection with the lamina-casting species the following may be mentioned: —

Desmarestia aculeata has been collected bearing the brown, assimilatory hairs in March—May in SW. Iceland, in May in NW. Iceland, in June in E. Iceland, and in July in N. Iceland. This appears to indicate that the hair-bearing stage occurs later on the north and east coasts, or that it lasts longer. The species behaves in the same manner in Greenland (Rosenvinge, 61, p. 857) where the hairs are cast off, at the latest, in June in South Greenland, while hair-bearing individuals are found in July and August in North Greenland. In the Færöes it has been observed with hairs upon it in May—June (Börgesen, 13, p. 445), but hair-bearing individuals were, however, rare in June. On the west coast of

Sweden (Kylin, 45) the hairs are cast in June, but (young) hair-bearing individuals may, however, be met with in July.

Polysiphonia urceolata has hair-leaves in the spring, summer and beginning of autumn, but individuals without hairs are found side by side with hair-bearing ones from May to August. In December only hairless individuals have been observed at Reykjavík, and in January—February only hairless plants have been collected in N. Iceland.

Rhodomela lycopodioides has been collected with hair-leaves in March—July, and hairless in June—August in SW. Iceland; with hair-leaves in April—December, and hairless in July—August in N. Iceland; with hair-leaves in June—July and hairless in May—July in E. Iceland. In the autumn this species had cast off its leaves and branches in SW. Iceland.

In addition to this, the following instances of the occurrence of young shoots may be mentioned: —

Odonthalia dentata. The young shoots in this species are readily recognized by their paler red colour. Material from January—February bears young shoots. The latter are easily recognizable in January, and have probably begun to grow out in December. The young shoots then increase in size, and the colour becomes gradually darker month by month. In material collected in June—July the length of the year's shoot may even then be determined in some of the individuals, but I believe, however, that it is in July that the shoot is almost full-grown.

Polysiphonia fastigiata has young shoots in December at Reykjavík.

Odonthalia shows distinctly the period of development of the vegetative shoots in the sublittoral zone, and I presume it may be taken for granted that the other sublittoral species do not differ very much from it as regards this point.

In Greenland the formation of the new shoots begins in February—March (Rosenvinge, 63, p. 239), and the growth is continued until August or during the whole summer.

In the Færöes the new shoots begin to appear in the latter part of autumn (Börgesen, 12, p. 828).

From Spitzbergen (Kjellman, 36) some sublittoral species are known which form new shoots during the winter, as for instance, *Delesseria sinuosa* in January, and *Rhodymenia palmata* from November to May.

The Fruiting Period. In the table given below is indicated the time at which the species have been found in fruit. A + signifies that the greater part of the individuals in the samples gathered were fruiting; a ± signifies that fruiting and sterile individuals occurred in almost equal abundance, or sometimes that only a few fruiting individuals occurred; a — signifies that only sterile individuals of the species were found.

In the majority of the annual species the fruiting period coincides with the vegetative stage, and thus growing vegetative shoots and sporangia are frequently found on the same individual. These species fruit comparatively quickly and the young, or purely vegetative, stage is of short duration. The fruiting period extends over spring and summer probably in the case of the majority of the species. They do not, however, behave similarly in this respect in the different coastal districts. *Urospora Wormskioldii*, *Monostroma Grevillei*, *M. undulatum*, *Ectocarpus tomentosoides* and *Litosiphon filiformis* are all decidedly spring plants at Reykjavík, but in E. Iceland they have been found bearing fruit far into the summer. *Leathesia difformis* is a decidedly summer species at Reykjavík, it has been observed fruiting in June, July, August and even into September, but it was dying away in the middle of September. At Reykjavík its life-period coincides with its fruiting-period, but in N. Iceland it has been gathered in a sterile condition in September. This species appears to behave in the same manner on the west coast of Sweden (Kylin, 45) as at Reykjavík. Moreover the fact may be emphasized that at the latter place *Enteromorpha Linza* is usually a summer and autumn species.

With regard to the perennial species, it happens both that the vegetative growth and the fruit-formation is simultaneous, and also that the two stages occur at different times. A purely vegetative, young stage, more prolonged than in the annuals, is found in several of the perennials; thus, I think that I have seen indications of *Alaria* and *Laminaria* species being in a purely vegetative stage throughout the first year and perhaps longer.

Kylin (45, p. 274) divides the perennial species into three groups according to their life-activity: —

Group 1 includes species which carry on vegetative and reproductive work all the year round.

Group 2. Species which carry on vegetative work the whole year, but reproductive work only for a part of the year.

Group 3. Species which carry on vegetative and reproductive work only during a part of the year.

In referring the Icelandic species to these groups the difficulty at once arises, that we lack knowledge regarding the behaviour of a number of the species during winter. Such species cannot therefore be grouped with any certainty at the present time. True, we may judge with some probability how they behave here during winter by a comparison of their winter-activities in other places, provided these are known; but as it has been shown that one and the same species often behaves differently in two distantly situated places, a satisfactory result could not be arrived at through such a comparison which has, for that reason, been omitted. I therefore mention a few species only, which I think I can group with some certainty.

Group 1. The following species belong to this group: — *Hildenbrandia rosea* which fruits all the year round. *Rhodymenia palmata*: it might appear doubtful whether this species should be classed as a perennial. Kjellman (36, p. 150) regards it as an annual plant which forms tetraspores twice, once as a young plant and the second time just before it dies. It appears to me that the new shoots which arise early in spring from evidently old fronds, show that it lives through at any rate more than one period of growth. *Pelvetia canaliculata* bears fruit and carries on vegetative work the whole year at Reykjavík. In December—January the fruiting individuals were comparatively few, but there was a quantity of young plants almost all of which were in the "rosette" stage. It is perhaps doubtful if this species belongs to this group at all.

Group 2. The *Fucaceæ* belong to this group (with the exception of *Pelvetia* (?)). *Fucus spiralis* produces fruit in spring, summer and autumn. In December (1911) it was sterile, and young plants were found in quantities.

Ascophyllum nodosum, Fucus vesiculosus and *Fucus inflatus*, all these behave almost similarly. In December and January I saw, here and there, individuals with very young receptacles, but by far the greater part were sterile. In spring and early summer these species are found everywhere with full-grown receptacles. In the latter half of August they are sterile everywhere and at that time only a few individuals, which must be regarded as stragglers, are found bearing receptacles. Of *F. inflatus* I saw no stragglers in August. In September also they are sterile. In the first half of October

both *Ascophyllum* and *F. inflatus* are sterile, but at that time a few individuals of *F. vesiculosus* bear young receptacles. From the middle of October until December there are no observations to hand from Reykjavík. The usual course, with regard to these species, appears to be as follows: In the latter part of the autumn the development of the sexual organs begins, and is continued throughout the winter; in March the species are found everywhere with ripe sexual organs and the spores continue their development until the latter part of the summer.

Kjellman (36, p. 195) records with regard to *Ascophyllum nodosum* in Finmark, that it had numerous receptacles in July and the first half of August, was sterile in the latter part of August, and that new receptacles had begun to appear in October. Foslie (18, p. 64) records with regard to the same species in East Finmark that it has abundant receptacles in July and is sterile in August.

In the Færöes (Börgesen, 12, p. 830) *Ascophyllum nodosum* has young receptacles in December and fruits during the whole summer.

On the west coast of Sweden the sexual organs begin to develop late in August or early in winter (Kylin, 45, p. 106), and by the beginning of June the receptacles have fallen off.

Fucus inflatus probably behaves in East Finmark in a similar manner as at Reykjavík. Foslie (18, p. 67) mentions receptacle-bearing individuals in June—July and the first part of August. At Spitzbergen it bears fruit during winter and Kjellman (36, p. 204) found germinating spores in December, January, February and March.

To Group 2 belong, in addition, probably all the *Laminariaceæ, Rhodochorton Rothii, Polysiphonia urceolata, Halosaccion, Gigartina mamillosa, Odonthalia* and probably many more. *Petrocelis Hennedyi* belongs also most nearly to this group; it has been found producing fruit the whole year, but in spring, summer and autumn only a few fruiting crusts are found, while the winter appears to be the ordinary fruiting period. *Chætopteris plumosa* I include, although with doubt, in this group.

Group 3. To this belong *Desmarestia aculeata,* which has been found fruiting in October, *Rhodomela lycopodioides, Delesseria sanguinea* and others.

The Fruiting-period of the Species.

	Spring	Summer	Autumn	Winter
Bangia fuscopurpurea	+	+	+	
Porphyra umbilicalis	+	⊥	⊥	⊥
P. miniata	—	⊥	⊥	
Porphyropsis coccinea	—	—		
Conchocelis rosea	—	—	—	
Chantransia microscopica			—	
C. Alariæ		+		
C. secundata	+	⊥	⊥	
C. virgatula	+	⊥		
Chondrus crispus	+	+		
Gigartina mamillosa	—	+	⊥	—
Ahnfeltia plicata	—	—	—	—
Phyllophora Brodiæi * interrupta	—	—		
P. membranifolia	—	—	—	
Actinococcus subcutaneus	—	—		
Ceratocolax Hartzii	+			
Cystoclonium purpurascens	—	—	⊥	
Turnerella Pennyi	—	—		
Euthora cristata	⊥	⊥	+	
Rhodophyllis dichotoma	⊥	⊥		
Rhodymenia palmata	⊥	⊥	⊥	⊥
Lomentaria clavellosa	—	⊥		
L. rosea	—			
Plocamium coccineum	⊥	+	—	
Halosaccion ramentaceum	⊥	⊥	—	⊥
Delesseria alata	⊥	⊥	—	
D. sinuosa	⊥	⊥	⊥	
D. sanguinea	—	—	⊥	+
Pterosiphonia parasitica	+			
Polysiphonia urceolata	⊥	⊥	⊥	—
P. fastigiata	⊥	⊥	—	⊥
P. arctica	—	⊥	—	
P. nigrescens		—	+	
Rhodomela lycopodioides	+	+	⊥	—
Odonthalia dentata	—	⊥	⊥	+
Callithamnion Arbuscula	⊥	+		
C. scopulorum	⊥	⊥		
Plumaria elegans	⊥	⊥	+	—
Ptilota plumosa	⊥	⊥	+	+
P. pectinata	⊥	⊥	⊥	
Antithamnion Plumula * boreale	—	⊥		
A. floccosum	⊥	⊥		
Ceramium acanthonotum	—	—		
C. Deslongchampii		—		
C. fruticulosum		+		

The Fruiting-period of the Species (continued).

	Spring	Summer	Autumn	Winter
Ceramium circinnatum		+		
C. arborescens		+		
C. atlanticum	—	+		
C. rubrum	+	+	+	
Rhodochorton Rothii	+	⊥	—	—
R. repens	+			
R. minutum		+		
R. penicilliforme	+	+		
R. membranaceum	+	⊥		
Dumontia filiformis	+	+		
Dilsea edulis		—		
Petrocelis Hennedyi	⊥	⊥	⊥	+
Cruoria arctica	—	+		
C. pellita		+		
Peyssonellia Rosenvingii	—	—	—	
Rhododermis parasitica	+	+		
Lithothamnion glaciale	—	—	—	
L. Ungeri	—	—		
L. tophiforme		—	—	
L. flavescens		—		
L. foecundum		—		
L. læve	—	—		
L. Lenormandi	—	—		
Phymatolithon polymorphum	—	—		
Clathromorphum compactum	—	—	—	—
Lithophyllum Crouani	—	—		
Dermatolithon macrocarpum	+	+		
Corallina officinalis	—	⊥	—	
Hildenbrandia rosea	+	+	+	⊥
Phæophyceæ.				
Lithoderma fatiscens	—	⊥	—	—
Petroderma maculiforme				+
Ralfsia ovata		+	+	
R. clavata	⊥	⊥	—	+
R. verrucosa		⊥	⊥	
R. deusta	—	—	—	
Myrionema vulgare	—	—		
M. Corunnæ	+	+		
M. globosum	+	+	+	
M. færöense	+			
M. Laminariæ		+		
Ascocyclus islandicus			+	
Microsyphar Polysiphoniæ		⊥		
Streblonema æcidioides		+	+	

The Fruiting-period of the Species (continued).

	Spring	Summer	Autumn	Winter
Streblonema Stilophoræ v. cæspitosa	+	+	+	
Pylaiella littoralis	+	+	+	—
Ectocarpus tomentosoides	+	+	+	
E. tomentosus	+	+		
E. confervoides	+	+	+	
E. siliculosus	+	+	+	
E. penicillatus	+	+		
E. fasciculatus	+	+		
E. Hinksiæ	+			
Leptonema fasciculatum v. subcylindrica	+	+	+	
Elachista fucicola	⊥	⊥	⊥	⊥
Sphacelaria britannica	⊥	—	—	
S. radicans	—	⊥		+
S. olivacea	—	—		
Chætopteris plumosa	—	—	—	+
Omphalophyllum ulvaceum		+		
Punctaria plantaginea	⊥	—	+	
Litosiphon filiformis	+	+	⊥	
Isthmoplea sphærophora	⊥	+		
Stictyosiphon tortilis	—	⊥		
Phæostroma pustulosum	+	+		
Scytosiphon Lomentaria	+	+	+	
Phyllitis zosterifolia	+	⊥	—	
P. fascia	⊥	⊥	⊥	
Coilodesme bulligera	+	+		
Dictyosiphon Ekmani		+		
D. Mesogloia		+	+	
D. Chordaria		+		
D. corymbosus		+		
D. hippuroides		+	+	
D. foeniculaceus	—	⊥		
Desmarestia viridis	—	—	—	
D. aculeata	—	—	+	—
D. ligulata		—		
Castagnea virescens		+	+	
Leathesia difformis		+	⊥	
Chordaria flagelliformis	—	⊥	+	+
Chorda tomentosa		+		
C. Filum	—	⊥	+	
Saccorrhiza dermatodea	—	⊥	⊥	+
Laminaria saccharina	⊥	⊥	—	+
L. færöensis		+		—
L. nigripes		—		
L. digitata	⊥	⊥		—
L. hyperborea	+	—	—	—

The Fruiting-period of the Species (continued).

	Spring	Summer	Autumn	Winter
Alaria Pylaii	—	+	+	
A. esculenta	—	+	+	—
Fucus spiralis	+	+	+	—
F. inflatus	+	⊥	—	—
F. serratus	+		+	
F. vesiculosus	+	⊥	⊥	⊥
Pelvetia canaliculata	+	+	+	⊥
Ascophyllum nodosum	+	+	⊥	—
Chlorophyceæ.				
Chlorochytrium Cohnii		+		
C. inclusum		+	—	—
C. dermatocolax	—	—	—	
C. Schmitzii		—		
Codiolum Petrocelidis	—	—	—	—
C. gregarium		—		
C. pusillum			+	
Percursaria percursa		+		
Enteromorpha aureola		+		
E. Linza	—	—	+	
E. intestinalis	+	+	+	—
E. clathrata		⊥	—	
Monostroma groenlandicum	—	+		
M. Grevillei	+	+		
M. undulatum	+	+		
M. fuscum	+	+	+	⊥
Ulva lactuca	+	+	—	
Prasiola polyrrhiza	—			
P. furfuracea		—		
P. stipitata	—	—	—	—
Ulothrix consociata var. islandica	—	+		
U. subflaccida		+	—	
U. pseudoflacca	+	+		
U. flacca	+	+		
Pseudendoclonium submarinum		—		
Entoderma Wittrockii	+	—	—	
Acrochæte parasitica	—			
A. repens		+		
Bolbocoleon piliferum		+	+	
Ulvella fucicola	—	—	—	
Pringsheimia scutata	—	+		
Ochlochæte ferox			+	
Urospora mirabilis	+	+	+	
U. Hartzii	+	+		
U. Wormskioldii	+	+		

The Fruiting-period of the Species (continued).

	Spring	Summer	Autumn	Winter
Chætomorpha tortuosa	—	—	—	
C. Melagonium	+	⊥	—	
Rhizoclonium riparium	—	⊥	—	—
Spongomorpha vernalis		+	+	
Acrosiphonia albescens	+	+	+	
A. incurva	+	+	+	
A. hystrix	+	+		
A. flabelliformis	—			
A. penicilliformis		+		
Cladophora rupestris	⊥	—	⊥	—
C. hirta	—		+	
C. sericea	+	+	+	—
C. glaucescens		—		
C. gracilis		—	—	
Gomontia polyrrhiza	⊥	⊥	+	
Ostreobium Queketti	—	—	—	
Cyanophyceæ.				
Pleurocapsa amethystea	—	—	—	—
Plectonema norvegicum			—	
Phormidium autumnale		—		
Spirulina subsalsa		—	—	
Calothrix scopulorum		—	—	
Rivularia atra			—	

By looking through the above table it is seen that in the case of a number of species the fructification-period is of long extent. Some nine species have been found fruiting all the year round, but I presume that by future investigations it will be proved that many more species bear fruit during the whole year. Kjellman (36) mentions 11 species which bear fruit all the year round in the Arctic Sea, and Rosenvinge (63) mentions 6 species which fruit all the year round along the coast of Greenland, and he adds that probably there are many more.

If we consult the table as to which season of the year is richest in fruit-bearing species it is easily seen that summer stands highest, with 64 % of the total number of species; then comes spring with 42 %, and after that autumn with 33 %. As the conditions during winter are so very little known no percentages can be given for that season.

It is well-known (Kjellman, Rosenvinge, Börgesen) that

in the case of many species both the vegetative period and the period of fructification is longer in the Arctic Sea and the northern part of the Atlantic Ocean than in the remaining more southern part of the boreal area of the same Ocean. It holds good also for Iceland, that both these periods are prolonged. Iceland, the Færöes and Greenland agree also in the fact that the summer is richest in fruit-bearing species.

3. Littoral Winter-vegetation at Reykjavík.

The littoral vegetation changes its appearance according to the season, and this is especially owing to the annual species. The vegetation is most luxuriant, and richest in species during spring and early summer; in the latter part of the summer the annual species decrease in number and a quantity of them disappear, and in the autumn only a small number of them is left. During winter only a few short-lived species are found, and some of them play either no part, or only an unimportant one in the vegetation which by that time is usually composed of perennial species. Thus, the number of the species of the winter-vegetation is much less than of the summer-vegetation because the *Chlorophyceæ*, which is the group in the littoral zone that is richest in species during summer, are few in number during winter; also the number of species of the *Phæophyceæ* is greatly reduced in the littoral zone during winter. It is the *Fucaceæ* which form by far the greater part of the mass of plants in the littoral zone, during the winter as in the other seasons of the year.

In December and January, in the winter 1911—1912, the vegetation of the upper and lower littoral zones was composed as follows: —

Highest of all a Prasioletum stipitatæ occurred in patches. *Prasiola stipitata* grew luxuriantly and had a normal appearance. It was not injured by the winter climate.

Below that came a well-developed Porphyretum umbilicalis, occurring also in patches on account of the surface-form of the coast. The *Porphyra* was both sterile and in fruit and had an entirely normal appearance.

Below that again came the *Fucaceæ*-community which, as is usually the case there, consisted at the top of a *Pelvetia-Fucus spiralis*-belt and at the bottom of the usual *Fucus*-belt *(Fucus vesi-*

culosus, *Ascophyllum nodosum* and *Fucus inflatus)*. The vegetation was as luxuriant during winter as in the other seasons of the year when, however, the epiphyte-vegetation of the *Fucus*-belt is excepted. For further information concerning the *Fucaceæ* see p. 173. Epiphytes, for instance such as *Pylaiella littoralis* and *Elachista fucicola*, which at the other seasons of the year are common everywhere in the *Fucus*-belt, were not observed. On the other hand, *Polysiphonia fastigiata* occurred in abundance on *Ascophyllum*. Of intermixed species in the *Fucus*-belt *Cladophora rupestris* may specially be mentioned; it occurred abundantly as well-developed specimens with the uppermost apex of the shoots destroyed.

A Hildenbrandietum occurred everywhere in the littoral zone, of similar appearance and extent as at the other seasons of the year.

In rock-crevices at the level of the *Fucus*-belt a well-developed Rhodochortonetum Rothii was found. The *Rhodochorton* was sterile and *Pleurocapsa amethystea* was growing upon it. In such crevices were noted in addition: — *Pylaiella littoralis*, sterile and in very small quantity; *Acrosiphonia* sp., a few filaments; *Cladophora rupestris*, abundant; *Polysiphonia urceolata*, sterile and without hairs and sparse, and *Callithamnion* sp.

The vegetation of the Pools was on the whole very poorly developed. The upper pools, at the level of *Pelvetia* and *Fucus spiralis*, contained a few small individuals of *Cladophora sericea* f., a few filaments of *Pylaiella littoralis*, a few small individuals of *Monostroma fuscum*, and Diatoms in abundance. In such pools *Cladophora sericea* forms a dense and luxuriant vegetation in spring and summer. *Fucus inflatus f. linearis* grows also in these pools in spring and summer, but was not found there in winter. It appears as if this form is annual, at any rate in the upper pools. The lower pools, almost at the level of the lower part of the *Fucus*-belt, contained only a poor vegetation. *Monostroma fuscum*, however, occurred fairly abundantly, but *Halosaccion ramentaceum* was found more sparsely; on *Halosaccion* was growing *Elachista fucicola* v. *lubrica* with unilocular sporangia and somewhat sparse assimilatory filaments, and also *Ceramium* sp.

Below the *Fucus*-belt, in the lower littoral zone (upper part of the semilittoral belt) were found at Efferseyjargrandi, Rhodymenieta distributed in patches here and there, many of them of rather considerable size. The majority of the individuals were old,

with abundance of new shoots. The *Rhodymenia*-vegetation is never really luxuriant in this place; it attains, however, to a greater luxuriancy in spring and summer than during winter. Halosaccioneta occurred also here and there, but sparsely and not nearly as abundantly as in spring and summer, but the same applies to it, as to *Rhodymenia*, that it never grows really luxuriantly in this place. There were noted in addition: — *Monostroma fuscum*, *Pylaiella littoralis* (extremely sparsely) and *Enteromorpha intestinalis* f. *prolifera*, also extremely sparsely. Lithodermeta occurred abundantly and were well-developed, but the species was sterile. A Sphacelarietum composed of *Sphacelaria radicans* was found here and there. The plants were low in growth, sterile and without hairs. A Gigartinetum occurred here and there of about the usual extent.

Just below the limit of low-tide I gathered the uppermost stragglers from the sublittoral zone. There *Laminaria saccharina*, *L. digitata*, *L. hyperborea* and *Alaria esculenta* f., were growing. All the *Laminarias* were sterile and the new laminæ had not begun to grow. The frond of the *Alaria* was usually torn in pieces; in the middle of the stipe there were old sporophylls. The uppermost part of the stipe, just below the leaf-base, was young and evidently growing. Lowermost in the part that was growing, small projections could be seen on the two sides, which were evidently the beginnings of new sporophylls.

The following species were found thrown ashore: — *Laminaria saccharina*, *L. digitata*, *L. hyperborea*, *Alaria esculenta* f., *Saccorrhiza dermatodea*, *Desmarestia aculeata*, *Odonthalia dentata*, *Petrocelis Hennedyi* richly fruiting (on *L. hyperborea*), *Rhodochorton Rothii* (on *L. hyperborea*), *Delesseria sanguinea* with the small tetraspore-bearing fronds, and *Ptilota plumosa* with tetraspores.

For the further understanding of the winter-life of the algæ it may be mentioned that the winter of 1911—1912 was unusually mild at Reykjavík.

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ERRATA.

P. 3, line 6, for of read off.
P. 29, line 15, for Kylin (43) read Kylin (45).

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